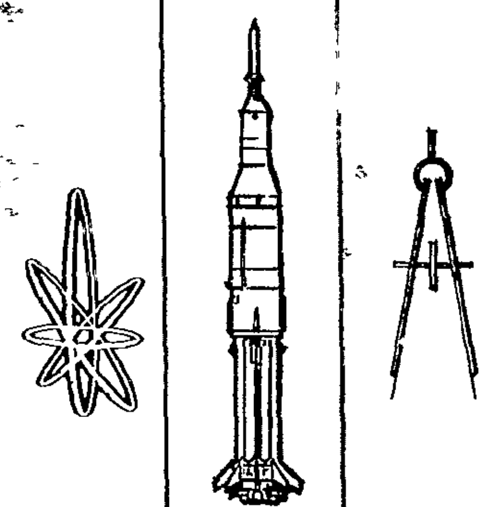
TECHNICAL REPORT HSM-R29-69

JULY 31, 1969

VOLUME TWO
USERS MANUAL FOR PROGRAM RANDOM

Contract No. NAS8-21403

FINAL REPORT
COMPUTER PROGRAMS FOR PREDICTION OF STRUCTURAL VIBRATIONS DUE TO FLUCTUATING PRESSURE ENVIRONMENTS



SPACE DIVISION CHRYSLER CORPORATION

HUNTSVILLE OPERATIONS

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COMPUTER PROGRAMS FOR PREDICTION OF STRUCTURAL VIBRATIONS DUE TO FLUCTUATING PRESSURE ENVIRONMENTS

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USERS' MANUAL FOR PROGRAM RANDOM

Contract No. NAS8-21403

Prepared for

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FOREWORD

The computer program presented in this report was developed for the Vibration and Acoustics Branch of the George C. Marshall Space Flight Center, National Aeronautics and Space Administration. This work has been accomplished by the Vibration and Acoustics Group, Structural Engineering Branch, Chrysler Corporation Space Division, Huntsville Operations.

SUMMARY

This computer program is to calculate the random vibrational response of a rectangular cylindrical shell panel cross-reinforced with ribs and stringers subjected to the excitation of fluctuating pressure environments. Three boundary conditions are considered: four edges simply supported; four edges clamped; and two opposite edges simply supported while the other two clamped. The special cases of a complete cylinder and a flat panel are included. This program is written so that either all three boundary conditions or any one boundary condition can be selected in any run. The normal mode approach is used in the formulations. Responses calculated are the acceleration, displacement, and stress spectral densities. Mean-square and root-mean-square values are also calculated. Output data are tabulated and plotted. This Manual is written according to the documentation requirements specified by the Computation Laboratory of MSFC. It contains three sections describing the problem, the programming, and the deck setup in detail.

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INTRODUCTION

Recent advancements in the mathematical formulations of solutions for structural responses due to random loading has made it feasible to develop computer programs for use by the structural engineer. The computer program reported in this manual calculates the random vibrational responses of rectangular cylindrical shell panels cross-reinforced with ribs and stringers. It is the result of a research project.

The program is written in FORTRAN IV language for the IBM 7094 computer. The results of this project are reported in two volumes.

1. Volume I - Theoretical Analyses

2. Volume II - User's Manual

The first volume contains the equations, technical discussion of the program, and analyses of the results. The second volume is oriented to utilization of the programs.

SECTION I. PROBLEM

A. Abstract

This is a program to compute the vibrational responses of a rectangular cylindrical shell panel cross-reinforced with stifeners, subjected to the excitation of fluctuating pressure environments. The boundary conditions considered are: four edges simply supported; four edges clamped, and two opposite edges simply supported while the other two clamped. The special cases of a complete cylinder and a flat panel are included The normal mode is used in the formulations. The responses are calculated as acceleration, displacement, and stress spectral densities, and the overall mean-square and root-mean-square values. The output data are tabulated and plotted. The program is written so that either all three boundary conditions or any one boundary condition can be selected in any run.

B. TECHNICAL DESCRIPTION

This is a program written to calculate the random vibrational responses of rectangular cylindrical shell panels cross-reinforced with stiffeners. Three boundary conditions are considered: four edges simply supported; four edges clamped; and two edges simply supported while the other two edges clamped. Special cases of flat panel and complete cylinder are included. The one-third-octave spectrum of the excitation pressure is read in as input in any discrete frequency. The program will apply when either the whole panel or a portion of the panel is exposed to the excitation The normal mode approach is used in the formulation. Analytical expressions for the joint acceptance are derived for all mode combinations. Contributions of the main terms as well as the cross terms are accounted for to obtain the responses. The responses at any point are calculated as displacement, acceleration and stress spectral densities. Mean-square and root-mean-square values of the responses are calculated by numerical integration. The response spectral densities are tabulated and plotted. The frequency range is from 5 (or lower) up to 5000 Hertz. One-nth-octave band is used for the frequency increment. The number of data points can be increased up to 500 for each spectral density plot. For each data point, 625 terms are summed to give the spectral density.

In addition to the excitation spectrum, the input data includes the geometric dimensions, material properties of the panel, and some control constants.

The program is written so that either all three boundary conditions or any one boundary condition can be calculated in any run.

Computed responses have been compared with experimental results, and the agreement is very good.

C. EQUATIONS

a. Subroutine RSR - Calculation of Response of Simply-Supported Rectangular Shell Panels Cross-Reinforced With Stiffeners

1. Natural Frequency

The undamped natural frequencies are given by

$$\omega_{mn} = \pi^2 M^{-1/2} \left\{ Dx \left(\frac{m}{\ell} \right)^4 + 2H\left(\frac{mn}{\ell b}\right)^2 + Dy \left(\frac{n}{b} \right)^4 + \frac{Eh}{a^2\pi^4 \left[1 + \left(\frac{\ell n}{bm}\right)^2 \right]^2} \right\}^{1/2} \tag{1}$$

$$M = \rho h + \rho' h'$$

ω_{mn} = frequency in rad./sec

$$D_x = \frac{Eh^3}{12(1-\nu^2)} + \frac{E' I_1}{b_1} \tag{1A}$$

$$D_y = \frac{Eh^3}{12(1-\nu^2)} + \frac{E' I_2}{a_1} \tag{1B}$$

$$H = \frac{Eh^3}{12(1-\nu^2)} \tag{1C}$$

Refer to Figure 1 for geometric dimensions.

a = radius of shell panel (input)

E = Young's modulus of panel (input)

E' = Young's modulus of stiffeners (input)

h = Thickness of panel skin (input)

h' = Smeared-out thickness of stiffeners (input)

ν = Poisson's ratio of panel (input)

a_1 = Spacing of y-direction stiffeners (input)

b_1 = Spacing of x-direction stiffeners (input)

I_1 = Moment of inertia of one x-direction stiffener with respect to neutral axis of cross-section of panel (input)

I_2 = Moment of inertia of one y-direction stiffener with respect to neutral axis of cross-section of panel (input)

ρ' = Mass density of stiffeners (input)

ρ = Mass density of panel (input)

2. Responses

The displacement response spectral density at point $\vec{r}(x,y)$ is given by

$$\Phi_{ww}(\vec{r},\omega) = S'^2\Phi_{pp}(\omega) \sum_{\substack{j,k,m,n \\ =1,2,3\,..}} F_{jk}(\vec{r})F_{mn}(\vec{r})|H_{jk}||H_{mn}|J^2_{jkmn} \tag{2}$$

where

$\Phi_{ww}(\vec{r},\omega)$ = Displacement spectral density in $\dfrac{\text{inch}^2}{\text{rad/sec}}$

S' = Area of panel subjected to excitation (inch^2)

$$= b'\ell' \tag{2A}$$

b' = Circumferential width of panel subjected to excitation (input)

ℓ' = Longitudinal length of panel subjected to excitation (input)

$$F_{jk}(\vec{r}) = \sin\frac{j\pi x}{\ell}\sin\frac{k\pi y}{b} = \text{normal mode} \tag{2B}$$

$$F_{mn}(\vec{r}) = \sin\frac{m\pi x}{\ell}\sin\frac{n\pi y}{b} = \text{normal mode} \tag{2C}$$

b = Width of panel (along y-axis) (input)

ℓ = Length of panel (along x-axis) (input)

$$M_{jk} = M_{mn} = \frac{Mb\ell}{4} \tag{2D}$$

$$M = \rho h + \rho' h' \tag{2E}$$

$\vec{r}$ = Position vector of point concerned

x,y = Coordinates of $\vec{r}$ (input)

ω = Frequency in rad/sec. = $2\pi f$

f = Frequency in Hertz (independent variable)

j,k,m,n = Mode indices

ω_{jk} = Undamped natural frequncies given by Equation (1)

The magnitudes of the frequency response functions are:

$$|H_{jk}| = \frac{1}{M_{jk}\left[(\omega_{jk}^2 - \omega^2)^2 + (2\zeta_{jk}\omega_{jk}\omega)^2\right]^{1/2}} \tag{2F}$$

$$|H_{mn}| = \frac{1}{M_{mn}\left[(\omega_{mn}^2 - \omega^2)^2 + (2\zeta_{mn}\omega_{mn}\omega)^2\right]^{1/2}} \tag{2G}$$

The joint acceptances squared for different mode combinations are given by

$$J_{jkmn}^2 = J_{jm}J_{kn}\frac{A_{jkmn}}{C_{jkmn}} \quad \text{for} \quad j=m, \quad k=n$$

$$J_{jkmn}^2 = J_{jm}J'_{kn}\frac{A_{jkmn}}{C_{jkmn}} \quad \text{for} \quad j=m, \quad k\neq n$$

$$J_{jkmn}^2 = J'_{jm}J_{kn}\frac{A_{jkmn}}{C_{jkmn}} \quad \text{for} \quad j\neq m, \quad k=n$$

$$J_{jkmn}^2 = J'_{jm}J'_{kn}\frac{A_{jkmn}}{C_{jkmn}} \quad \text{for} \quad j\neq m, \quad k\neq n \tag{2H}$$

where

$$J_{jm} = \frac{\frac{A_2\ell\omega}{c}}{2}\left[\frac{1}{\left(\frac{A_1\ell\omega}{c}\right)^2 + (j\pi)^2} + \frac{1}{\left(\frac{A_1\ell\omega}{c}\right)^2 + (m\pi)^2}\right]$$

$$+ (j\pi)(m\pi)\frac{2 + e^{-\frac{A_1\ell\omega}{c}}\left[(-1)^{j+1} + (-1)^{m+1}\right]}{\left[\left(\frac{A_1\ell\omega}{c}\right)^2 + (j\pi)^2\right]\left[\left(\frac{A_1\ell\omega}{c}\right)^2 + (m\pi)^2\right]} \tag{2I}$$

$$J_{kn} = \frac{\frac{A_2 b\omega}{c}}{2}\left[\frac{1}{\left(\frac{A_2 b\omega}{c}\right)^2 + (k\pi)^2} + \frac{1}{\left(\frac{A_2 b\omega}{c}\right)^2 + (n\pi)^2}\right]$$

$$+ (k\pi)(n\pi)\,\frac{2 + e^{-\frac{A_2 b\omega}{c}}\left[(-1)^{k+1} + (-1)^{n+1}\right]}{\left[\left(\frac{A_2 b\omega}{c}\right)^2 + (k\pi)^2\right]\left[\left(\frac{A_2 b\omega}{c}\right)^2 + (n\pi)^2\right]} \tag{2J}$$

$$J'_{jm} = (j\pi)(m\pi)\,\frac{2 + e^{-\frac{A_1 \ell\omega}{c}}\left[(-1)^{j+1} + (-1)^{m+1}\right]}{\left[\left(\frac{A_1 \ell\omega}{c}\right)^2 + (j\pi)^2\right]\left[\left(\frac{A_1 \ell\omega}{c}\right)^2 + (m\pi)^2\right]}$$

$$+ \frac{m}{\left(\frac{A_1 \ell\omega}{c}\right)^2 + (m\pi)^2}\left[\frac{(-1)^{j-m} - 1}{2(j-m)} + \frac{(-1)^{j+m} - 1}{2(j+m)}\right]$$

$$+ \frac{j}{\left(\frac{A_1 \ell\omega}{c}\right)^2 + (j\pi)^2}\left[\frac{(-1)^{m-j} - 1}{2(m-j)} + \frac{(-1)^{m+j} - 1}{2(m+j)}\right] \tag{2K}$$

$$J'_{kn} = (k\pi)(n\pi)\,\frac{2 + e^{-\frac{A_2 b\omega}{c}}\left[(-1)^{k+1} + (-1)^{n+1}\right]}{\left[\left(\frac{A_2 b\omega}{c}\right)^2 + (k\pi)^2\right]\left[\left(\frac{A_2 b\omega}{c}\right)^2 + (n\pi)^2\right]}$$

$$+ \frac{n}{\left(\frac{A_2 b\omega}{c}\right)^2 + (n\pi)^2}\left[\frac{(-1)^{k-n} - 1}{2(k-n)} + \frac{(-1)^{k+1} - 1}{2(k+n)}\right]$$

$$+ \frac{k}{\left(\frac{A_2 b\omega}{c}\right)^2 + (k\pi)^2}\left[\frac{(-1)^{n-k} - 1}{2(n-k)} + \frac{(-1)^{n+k} - 1}{2(n+k)}\right] \tag{2L}$$

where

A_1 = Decay constant in x-direction (input)

A_2 = Decay constant in y-direction (input)

c = Speed of sound (input)

$$A_{jkmn} = \left[1 - \left(\frac{\omega}{\omega_{jk}}\right)^2\right]\left[1 - \left(\frac{\omega}{\omega_{mn}}\right)^2\right] + 4\zeta_{jk}\zeta_{mn}\frac{\omega^2}{\omega_{jk}\omega_{mn}}$$

$$C^2_{jkmn} = A^2_{jkmn} + B^2_{jkmn}$$

$$B_{jkmn} = -2\left\{\frac{\zeta_{jk}\omega}{\omega_{jk}}\left[1 - \left(\frac{\omega}{\omega_{mn}}\right)^2\right] - \frac{\zeta_{mn}\omega}{\omega_{mn}}\left[1 - \left(\frac{\omega}{\omega_{jk}}\right)^2\right]\right\} \tag{2L}$$

The excitation spectral density in $\frac{(psi)^2}{rad/sec}$,

$\Phi_{pp}(\omega)$, is given by

$$\Phi_{pp}(\omega) = \frac{1}{2\pi}(10)^{\frac{S_{pp}(f) - 170.576}{10}} \tag{2M}$$

The excitation spectral density in decibels per Hertz, $S_{pp}(f)$, is given by

$$S_{pp}(f) = S_{3rd}(f) - 10\log_{10}(0.23157f) \tag{2N}$$

where

$S_{3rd}(f)$ = One-third octave excitation pressure level in decibels (input)

The acceleration response spectral density at $\vec{r}(x,y)$ in

$\left(\frac{inch}{sec^2}\right)^2 \frac{1}{rad/sec}$ is given by

$$\Phi_{ww}(\vec{r},\omega) \quad = \quad \omega^4 \Phi_{ww}(\vec{r},\omega) \tag{3}$$

The acceleration response spectral density in $\frac{g^2}{\text{Hertz}}$ is given by

$$S_{ww}(\vec{r},f) \quad = \quad 4.215093 \times 10^{-5} \; \Phi_{ww}(\vec{r},\omega) \tag{4}$$

The mean-square acceleration in "g^2" is given by

$$G^2(\vec{r}) \quad = \quad \int S_{\dot{w}w}(\vec{r},f)\,df \tag{5}$$

The root-mean-square acceleration in "g" is given by

$$G(\vec{r}) \quad = \quad \sqrt{G^2(\vec{r})} \tag{6}$$

The stress spectral density in $\frac{(\text{psi})^2}{\text{rad per sec}}$ is given by

$$\Phi_{\sigma\sigma}(\vec{r},\omega) \quad = \quad \gamma^2 \Phi_{ww}(\vec{r},\omega) \tag{7}$$

where

$\Phi_{ww}(\vec{r},\omega)$ is given by Equation (2)

$$\gamma^2 \quad = \quad \gamma^2(\vec{r}) = \frac{(Eh_1)^2}{4(1-\nu^2)^2} \cdot \frac{Q_x^2 + Q_y^2}{Q_w^2}$$

$$h_1 \quad = \quad h + h_2$$

h_2 = largest height of stiffeners at $\vec{r}$, see Figure 1 (input)

$$Q_x = \sum_{\substack{m,n \\ =1,3\ldots}}^{\infty} \left[\left(\frac{m\pi}{\ell}\right)^2 + \nu \left(\frac{n\pi}{b}\right)^2 \right] \frac{\sin \frac{m\pi x}{\ell} \sin \frac{n\pi y}{b}}{mn\left[D_x \left(\frac{m}{\ell}\right)^4 + 2H \left(\frac{mn}{\ell b}\right)^2 + D_y \left(\frac{n}{b}\right)^4\right]}$$

$$Q_y = \sum_{\substack{m,n \\ =1,3\ldots}}^{\infty} \left[\left(\frac{n\pi}{b}\right)^2 + \nu \left(\frac{m\pi}{\ell}\right)^2 \right] \frac{\sin \frac{m\pi x}{\ell} \sin \frac{n\pi y}{b}}{mn\left[D_x \left(\frac{m}{\ell}\right)^4 + 2H \left(\frac{mn}{\ell b}\right)^2 + D_y \left(\frac{n}{b}\right)^4\right]}$$

$$Q_w = \sum_{\substack{m,n \\ =1,3\ldots}}^{\infty} \frac{\sin \frac{m\pi x}{\ell} \sin \frac{n\pi y}{b}}{mn\left[D_x \left(\frac{m}{\ell}\right)^4 + 2H \left(\frac{mn}{\ell b}\right)^2 + D_y \left(\frac{n}{b}\right)^4\right]} \tag{7A}$$

The stress spectral density in $(psi)^2$/ Hertz is given by

$$S_{\sigma\sigma}(\vec{r},f) = 2\pi\Phi_{\sigma\sigma}(\vec{r},\omega) \tag{8}$$

The mean-square stress is given by

$$\sigma^2(\vec{r}) = \int S_{\sigma\sigma}(\vec{r},f)df \tag{9}$$

The root-mean-square stress is given by

$$\sigma(\vec{r}) = [\ \sigma^2(r)\ ]^{1/2} \tag{10}$$

The displacement spectral density in $\dfrac{(\text{inch})^2}{\text{Hertz}}$ is

$$S_{ww}(\vec{r},f) = 2\pi\Phi_{ww}(\vec{r},\omega) \tag{11}$$

The mean-square displacement is

$$w^2(\vec{r}) = \int S_{ww}(\vec{r},f)df \tag{12}$$

The root-mean-square displacement is

$$w(\vec{r}) = \sqrt{w^2(\vec{r})} \tag{13}$$

b. SUBROUTINE RFR

DYNAMIC RESPONSE OF FOUR SIDES CLAMPED RECTANGULAR SHELL PANELS CROSS-REINFORCED WITH STIFFENERS

1 Natural Frequencies

The natural frequencies in radians per second are given by

$$\omega_{11} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{1.5056}{\ell} \right)^4 + D_y \left(\frac{1.5056}{b} \right)^4 + 2H \left(\frac{1.2466}{\ell b} \right)^2 + \frac{Eh}{a^2 \pi^4 \left[1 + \left(\frac{\ell}{b} \right)^2 \right]^2} \right\}^{1/2} \tag{1A}$$

$$\omega_{1k} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{1.5056}{\ell} \right)^4 + D_y \left(\frac{k + \frac{1}{2}}{b} \right)^4 + 2H \frac{1.2466 \, (k + \frac{1}{2}) [(k + \frac{1}{2}) - 0.6366]}{\ell^2 b^2} + \frac{Eh}{a^2 \pi^4 \left[1 + \left(\frac{k + \frac{1}{2}}{1.5056} \right)^2 \left(\frac{\ell}{b} \right)^2 \right]^2} \right\}^{1/2} \tag{1B}$$

$k = 2, 3, \ldots$

$$\omega_{j1} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{j + \frac{1}{2}}{\ell} \right)^4 + D_y \left(\frac{1.5056}{b} \right)^4 + 2H \frac{1.2466 \, (j + \frac{1}{2}) [(j + \frac{1}{2}) - 0.6366]}{\ell^2 b^2} + \frac{Eh}{a^2 \pi^4 \left[1 + \left(\frac{1.5056}{j + \frac{1}{2}} \right)^2 \left(\frac{\ell}{b} \right)^2 \right]^2} \right\}^{1/2} \tag{1C}$$

$j = 2, 3, \ldots$

$$\omega_{jk} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{j + \frac{1}{2}}{\ell} \right)^4 + D_y \left(\frac{k + \frac{1}{2}}{b} \right)^4 \right.$$

$$+ 2H \frac{(j + \frac{1}{2})\ (k + \frac{1}{2})[(j + \frac{1}{2}) - 0.6366][(k + \frac{1}{2}) - 0.6366]}{\ell^2 b^2}$$

$$\left. + \frac{Eh}{a^2 \pi^4 \left[1 + \left(\frac{k + \frac{1}{2}}{j + \frac{1}{2}} \right)^2 \left(\frac{\ell}{b} \right)^2 \right]^2} \right\}^{1/2} \tag{1D}$$

$j,k = 2,3,\ldots$

$$D_x = \frac{Eh^3}{12(1-\nu)^2} + \frac{E'I_1}{b_1}$$

$$D_y = \frac{Eh^3}{12(1-\nu^2)} + \frac{E'I_2}{a_1}$$

$$H = \frac{Eh^3}{12(1-\nu^2)}$$

$$M = \rho h + \rho' h' \tag{1E}$$

The natural frequencies in Hertz are given by

$$f_{jk} = \frac{\omega_{jk}}{2\pi} \tag{2}$$

E = Young's modulus of panel (input)

E' = Young's modulus of stiffeners (input)

h = Thickness of panel skin (input)

h' = Smeared-out thickness of stiffeners (input)

ν = Poisson's ratio of panel (input)

a = Radius of shell (input)

a_1 = Spacing of y-direction stiffeners (input)

b_1 = Spacing of x-direction stiffeners (input)

I_1 = Moment of inertia of one x-direction stiffener with respect to neutral axis of cross-section of panel (input)

I_2 = Moment of inertia of one y-direction stiffener with respect to neutral axis of cross-section of panel (input)

ρ = Mass density of panel skin (input)

ρ' = Mass density of stiffeners (input)

2. <u>Responses</u>

The displacement response spectral density at point $\vec{r}(x,y)$ is given by

$$\Phi_{ww}(\vec{r},\omega) = S'^2 \Phi_{pp}(\omega) \sum_{\substack{j,k,m,n \\ =1,2,3\ldots}} F_{jk}(\vec{r}) F_{mn}(\vec{r}) |H_{jk}| |H_{mn}| J^2_{jkmn} \tag{3}$$

where

$\Phi_{ww}(\vec{r},\omega)$ = displacement spectral density in $\dfrac{\text{inch}^2}{\text{rad/sec}}$

S' = Area of panel subjected to excitation (inch^2)

= $b'\ell'$

b' = Width of panel subjected to excitation (input)

ℓ' = Length of panel subjected to excitation (input)

$F_{jk}(\vec{r})$ = $X_j Y_k$ = normal mode

$F_{mn}(\vec{r})$ = $X_m Y_n$ = normal mode

$$X_1 = X_1(x) = \cosh \frac{1.5056\pi x}{\ell} - \cos \frac{1.5056\pi x}{\ell}$$

$$- 0.9825 \left(\sinh \frac{1.5056\pi x}{\ell} - \sin \frac{1.5056\pi x}{\ell} \right) \tag{4A}$$

$$Y_1 = Y_1(y) = \cosh \frac{1.5056\pi y}{b} - \cos \frac{1.5056\pi y}{b}$$

$$-0.9825 \left(\sinh \frac{1.5056\pi y}{b} - \sin \frac{1.5056\pi y}{b} \right) \tag{4B}$$

$$X_j = X_j(x) = \cosh \frac{(j + \frac{1}{2})\pi x}{\ell} - \cos \frac{(j + \frac{1}{2})\pi x}{\ell}$$

$$- \sinh \frac{(j + \frac{1}{2})\pi x}{\ell} + \sin \frac{(j + \frac{1}{2})\pi x}{\ell} \tag{4C}$$

$$Y_k = Y_k(y) = \cosh \frac{(k + \frac{1}{2})\pi y}{b} - \cos \frac{(k + \frac{1}{2})\pi y}{b}$$

$$- \sinh \frac{(k + \frac{1}{2})\pi y}{b} + \sin \frac{(k + \frac{1}{2})\pi y}{b} \tag{4D}$$

b = Width of panel ($y=0$ to $y=b$) (input)

ℓ = Length of panel ($x=0$ to $x=\ell$) (input)

$M_{jk} = M_{mn} = \frac{M\ell b}{4}$

$M = \rho h + \rho' h'$

$\vec{r}$ = Position vector of point concerned

x,y = Coordinates of $\vec{r}$ (input)

ω = Frequency in rad/sec = $2\pi f$

f = Frequency in Hertz (independent variable)

j,k,m,n = Mode indices

ω_{jk} = Undamped natural frequencies given by Equation (1)

The magnitudes of the frequency response functions H_{jk} and H_{mn} are given by equations (2F) and (2G) in Section a.

The joint acceptance squared for different mode combinations are given by equations (2H) through (2L) in Section a.

The displacement spectral density in $\frac{(\text{inch})^2}{\text{Hertz}}$ is given by

$$S_{ww}(\vec{r},f) = 2\pi\Phi_{ww}(\vec{r},\omega) \tag{8}$$

The mean square displacement in $(\text{inch})^2$ is

$$w^2(\vec{r}) = \int S_{ww}(\vec{r},f)df \tag{9}$$

The root-mean square displacement in inches is

$$w(\vec{r}) = \sqrt{w^2(\vec{r})} \tag{10}$$

The excitation spectral density in $\frac{(\text{psi})^2}{\text{rad/sec}}$ is

$$\Phi_{pp}(\omega) = \frac{1}{2\pi}(10)^{\frac{S_{pp}(f)-170.576}{10}} \tag{11}$$

The excitation spectral density in decibels per Hertz, $S_{pp}(f)$, is given by

$$S_{pp}(f) = S_{3rd}(f) - 10\log_{10}(0.23157f) \tag{12}$$

where

$S_{3rd}(f)$ = One-third octave excitation pressure level in decibels (input)

The excitation spectral density in $(\text{psi})^2$/Hertz is given by

$$S'_{pp}(f) = 2\pi\Phi_{pp}(\omega) \tag{12A}$$

The acceleration response spectral density at $\vec{r}(x,y)$ in $\left(\frac{\text{inch}}{\text{sec}^2}\right)^2 \cdot \frac{1}{\text{rad/sec}}$

is given by

$$\Phi_{\ddot{w}\ddot{w}}(\vec{r},\omega) = \omega^4 \Phi_{ww}(\vec{r},\omega) \tag{13}$$

The acceleration response spectral density in $\frac{g^2}{\text{Hertz}}$ is given by

$$S_{\ddot{w}\ddot{w}}(\vec{r},f) = 4.215093 \times 10^{-5}\ \Phi_{\ddot{w}\ddot{w}}(\vec{r},\omega) \tag{14}$$

The mean-square acceleration in "g^2" is given by

$$G^2(\vec{r}) = \int S_{\ddot{w}\ddot{w}}(\vec{r},f)\,df \tag{15}$$

The root-mean-square acceleration in "g" is given by

$$G(\vec{r}) = \sqrt{G^2(\vec{r})} \tag{15A}$$

The stress spectral density in $\frac{(\text{psi})^2}{\text{rad/sec}}$ is given by

$$\Phi_{\sigma\sigma}(\vec{r},\omega) = \gamma^2(\vec{r})\,\Phi_{ww}(\vec{r},\omega) \tag{16}$$

where $\Phi_{ww}(\vec{r},\omega)$ is given by Equation (3) and $\gamma^2(\vec{r})$ is given by Equation (7A) in Section a.

The stress spectral density in $\frac{(\text{psi})^2}{\text{Hertz}}$ is given by

$$S_{\sigma\sigma}(\vec{r},f) = 2\pi\Phi_{\sigma\sigma}(\vec{r},\omega) \tag{17}$$

The mean-square stress in $(\text{psi})^2$ is given by

$$\sigma^2(\vec{r}) = \int S_{\sigma\sigma}(\vec{r},f)\,df \tag{18}$$

The root-mean-square stress in psi is given by

$$\sigma(\vec{r}) = [\sigma^2(\vec{r})]^{1/2} \qquad (19)$$

c. SUBROUTINE RSF

DYNAMIC RESPONSE OF TWO OPPOSITE EDGES SIMPLY-SUPPORTED AND OTHER TWO CLAMPED RECTANGULAR SHELL PANELS UNDER RANDOM PRESSURE FIELD

Simply-Supported Edges: $x = 0, \quad x = \ell$
Fixed Sides: $y = 0, \quad y = b$

1. Natural Frequencies

The natural frequencies in radians per second are given by

$$\omega_{11} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{1}{\ell}\right)^4 + D_y \left(\frac{1.5056}{b}\right)^4 + 2H\left(\frac{1}{\ell}\right)^2 \left(\frac{1.1165}{b}\right)^2 + \frac{Eh}{a^2\pi^4 \left[1 + \left(\frac{1}{1.5056}\right)^2 \left(\frac{\ell}{b}\right)^2\right]^2} \right\}^{1/2} \tag{1A}$$

$$\omega_{1k} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{1}{\ell}\right)^4 + D_y \left(\frac{k+\frac{1}{2}}{b}\right)^4 + 2H\left(\frac{1}{\ell}\right)^2 \frac{(k+\frac{1}{2})[(k+\frac{1}{2})-0.6366]}{b^2} + \frac{Eh}{a^2\pi^4 \left[1 + \left(\frac{1}{k+\frac{1}{2}}\right)^2 \left(\frac{\ell}{b}\right)^2\right]^2} \right\}^{1/2} \tag{1B}$$

$k = 2,3, \ldots$

$$\omega_{j1} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{j}{\ell}\right)^4 + D_y \left(\frac{1.5056}{b}\right)^4 + 2H\left(\frac{j}{\ell}\right)^2 \left(\frac{1.1165}{b}\right)^2 + \frac{Eh}{a^2\pi^4 \left[1 + \left(\frac{j}{1.5056}\right)^2 \left(\frac{\ell}{b}\right)^2\right]^2} \right\}^{1/2} \tag{1C}$$

$j = 2, 3, \ldots$

$$\omega_{jk} = \pi^2 M^{-1/2} \left\{ D_x \left(\frac{j}{\ell}\right)^4 + D_y \left(\frac{k+\frac{1}{2}}{b}\right)^4 + 2H\left(\frac{j}{\ell}\right)^2 \frac{(k+\frac{1}{2})[(k+\frac{1}{2})-0.6366]}{b^2} + \frac{Eh}{a^2\pi^4 \left[1 + \left(\frac{j}{k+\frac{1}{2}}\right)^2 \left(\frac{\ell}{b}\right)^2\right]^2} \right\}^{1/2} \tag{1D}$$

$j, k = 2,3 \ldots$

$$D_x = \frac{Eh^3}{12(1-\nu^2)} + \frac{E'I_1}{b_1}$$

$$D_y = \frac{Eh^3}{12(1-\nu^2)} + \frac{E'I_2}{a_1}$$

$$H = \frac{Eh^3}{12(1-\nu^2)}$$

$$M = \rho h + \rho' h' \tag{1E}$$

The natural frequencies in Hertz are given by

$$f_{jk} = \frac{\omega_{jk}}{2\pi} \tag{2}$$

E = Young's modulus of panel (input)

E' Young's modulus of stiffeners (input)

h = Thickness of panel skin (input)

h' = Smeared-out thickness of stiffeners (input)

ν = Poisson's ratio of panel (input)

a = Radius of shell (Input)

a_1 = Spacing of y-direction stiffeners (input)

b_1 = Spacing of x-direction stiffeners (input)

I_1 = Moment of inertia of one x-direction stiffener with respect to neutral axis of cross section of panel (input)

I_2 = Moment of inertia of one y-direction stiffener with respect to neutral axis of cross section of panel (input)

ρ' = Mass density of stiffeners (input)

ρ = Mass density of panel skin (input)

2. Responses

The formulation for responses for Subroutine RSF are the same as Subroutine RFR given in Section b, except the normal modes are by the following expressions;

$$F_{jk}(\vec{r}) = X_j Y_k$$

$$F_{mn}(\vec{r}) = X_m Y_n \tag{4}$$

$$X_j = X_j(x) = \sin \frac{j\pi x}{\ell}$$

$$j = 1, 2, \ldots \tag{4A}$$

$$Y_1 = Y_1(y) = \cosh \frac{1.505\pi y}{b} - \cos \frac{1.505\pi y}{b}$$

$$-0.982 \left(\sinh \frac{1.505\pi y}{b} - \sin \frac{1.505\pi y}{b} \right) \tag{4B}$$

$$Y_k = Y_k(y) = \cosh \frac{(k + \frac{1}{2})\pi y}{b} - \cos \frac{(k + \frac{1}{2})\pi y}{b}$$

$$- \sinh \frac{(k + \frac{1}{2})\pi y}{b} + \sin \frac{(k + \frac{1}{2})\pi y}{b}$$

$$k = 2, 3, \ldots \tag{4C}$$

D. DEFINITION OF TERMS

MNEMONICS	FORMULAS	DESCRIPTION
SPPF(I)	$S_{pp}(f)$	Excitation spectral density in decibels per Hertz.
FIPW(I)	$\Phi_{pp}(\omega)$	Excitation spectral density in $(psi)^2$rad per sec.
FNW(J,K)	ω_{jk}	Nautral frequencies of panel
OMEGA	ω	Independent frequency variable for spectrum in rad/sec
POWJ2	J^2_{jkmn}	Joint acceptance squared
PIWW	$\Phi_{ww}(\vec{r},\omega)$	Displacement spectral density in $inch^2$/rad per sec
OMEG(I)	f	Independent frequency variable for spectrum in Hertz
SWW(I)	$S_{ww}(\vec{r},f)$	Displacement spectral density in in^2/Hertz
PIWG	$\Phi_{\dot{w}\dot{w}}(\vec{r},\omega)$	Acceleration spectral density in in^2/sec^4/ rad per sec
PIWG1(I)	$S_{\dot{w}\dot{w}}(\vec{r},f)$	Acceleration spectral density in g^2/Hertz
PSSW	$\phi_{\sigma\sigma}(\vec{r},\omega)$	Stress spectral density in psi^2/rad per sec
SSSF(I)	$S_{\sigma\sigma}(\vec{r},f)$	Stress spectral density in psi^2/Hertz
SPPP(I)	$S'_{pp}(f)$	Excitation spectral density in psi^2/Hertz
QX	Q_x	Quantity for the calculation of γ^2
QY	Q_y	Quantity for the calculation of γ^2
QW	Q_w	Quantity for the calculation of γ^2
GAM2	$\gamma^2(\vec{r})$	Constant to change displacement spectral density into stress
PAS	p^2_a	Overall mean square excitation pressure
$W^2(\vec{r})$	ATS1	Mean square displacement

D. DEFINITION OF TERMS (Continued)

MNEMONICS	FORMULAS	DESCRIPTION
$\sigma^2(\vec{r})$	ATS2	Mean square stress
$G^2(\vec{r})$	ATS3	Mean square acceleration
$W(r)$	AT1	Root-mean square displacement
$\sigma(\vec{r})$	AT2	Root-mean square stress
$G(\vec{r})$	AT3	Root-mean square acceleration

E. SPECIAL OPTIONS

This program can be easily modified to caluclate the acceleration spectral density in decible scale referenced gravity acceleration, and compute the vibro-acoustic transfer function Modification to calculate the average responses over the whole structure and to investigate the contribution of the cross terms to the response is also not difficult.

F. NUMERICAL METHODS OF SOLUTION

The calculation of the mean-square responses is by numerical integration of the area under the spectral density curve. However, the integration procedure is written inside the program and no integration subroutine is required.

G. TECHNICAL REFERENCES

1 Lee, T. N., "Computer Program for Prediction of Structural Vibrations to Fluctuating Pressure Environments," Contract No. NAS8-21403. Monthly Progress Reports 1 Through 11. August 1968 to June 1969.

H. RELATED PROJECTS

This computer program has been used in the project, "Comparative Analysis of Acoustic Testing Techniques," MSFC Contract NAS8-21425, which Chrysler Huntsville Operations is conducting from July 1, 1968, to July 31, 1969. Comparison of the computed responses with the experimental data shows good agreement.

SECTION II. PROGRAMMING

A. Library Subroutines

No non-system subroutine is required for this program.

B Program Subroutines

This program contains a short main driver program and five subroutines which are called in the following order:

1 Subroutine PRNT is used to print the output data.

2. Subroutine GRIDIV is a general grid subroutine for the SC 4020 and is called by the plot routine in subroutines RSR, RFR and RSF

3. Subroutine RSR is to calculate the frequencies and the responses of simply supported rectangular panels.

4. Subroutine RFR is to calculate the frequencies and the responses of the four-edges-clamped rectangular shell panels.

5. Subroutine RSF is to calculate the frequencies and the responses of panels with two edges simply supported, the other two clamped.

C. Special Input Tapes

None

D Special Output Tapes

A-8 is the plot tape used by the SC 4020 plotter.

E. Plots Generated

The following eleven plots are generated by this program. In all the plots, the frequency is the independent variable while the spectral density is the dependent variable

a Spectral density of the excitation pressure in decibles versus frequency in Hertz.

b. Spectral density of the excitation pressure in $(psi)^2$/Hertz versus the frequency in Hertz.

The following three plots are generated for each of the three boundary conditions

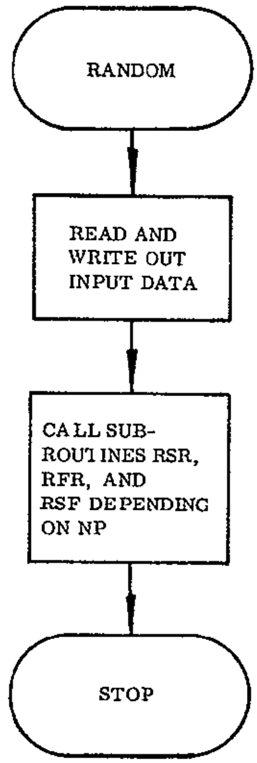
c. Acceleration spectral density in g^2/Hertz versus frequency in Hertz.

d. Displacement spectral density in $inch^2$/Hertz versus frequency in Hertz.

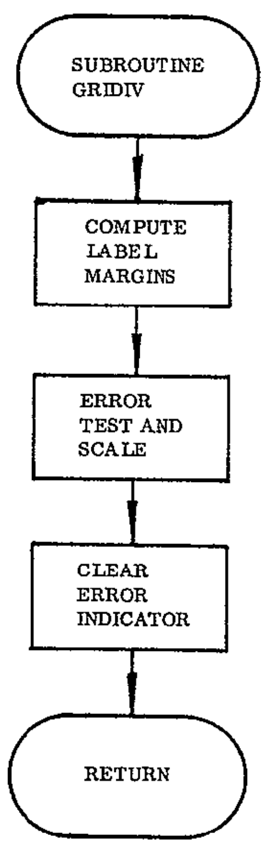
e. Stress spectral density in $(psi)^2$/Hertz versus frequency in Hertz.

F. BLOCK DIAGRAMS

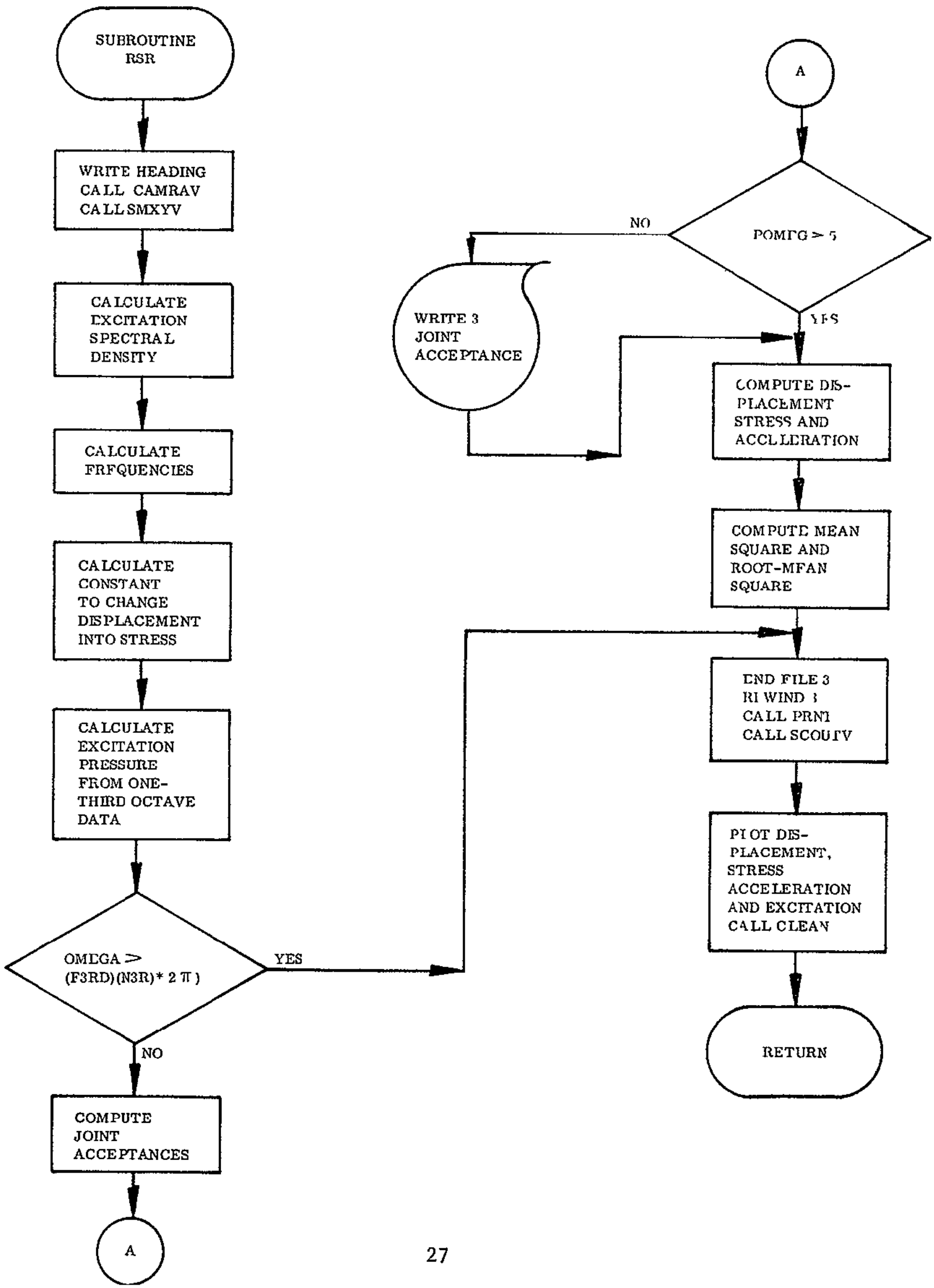
a. PROGRAM RANDOM



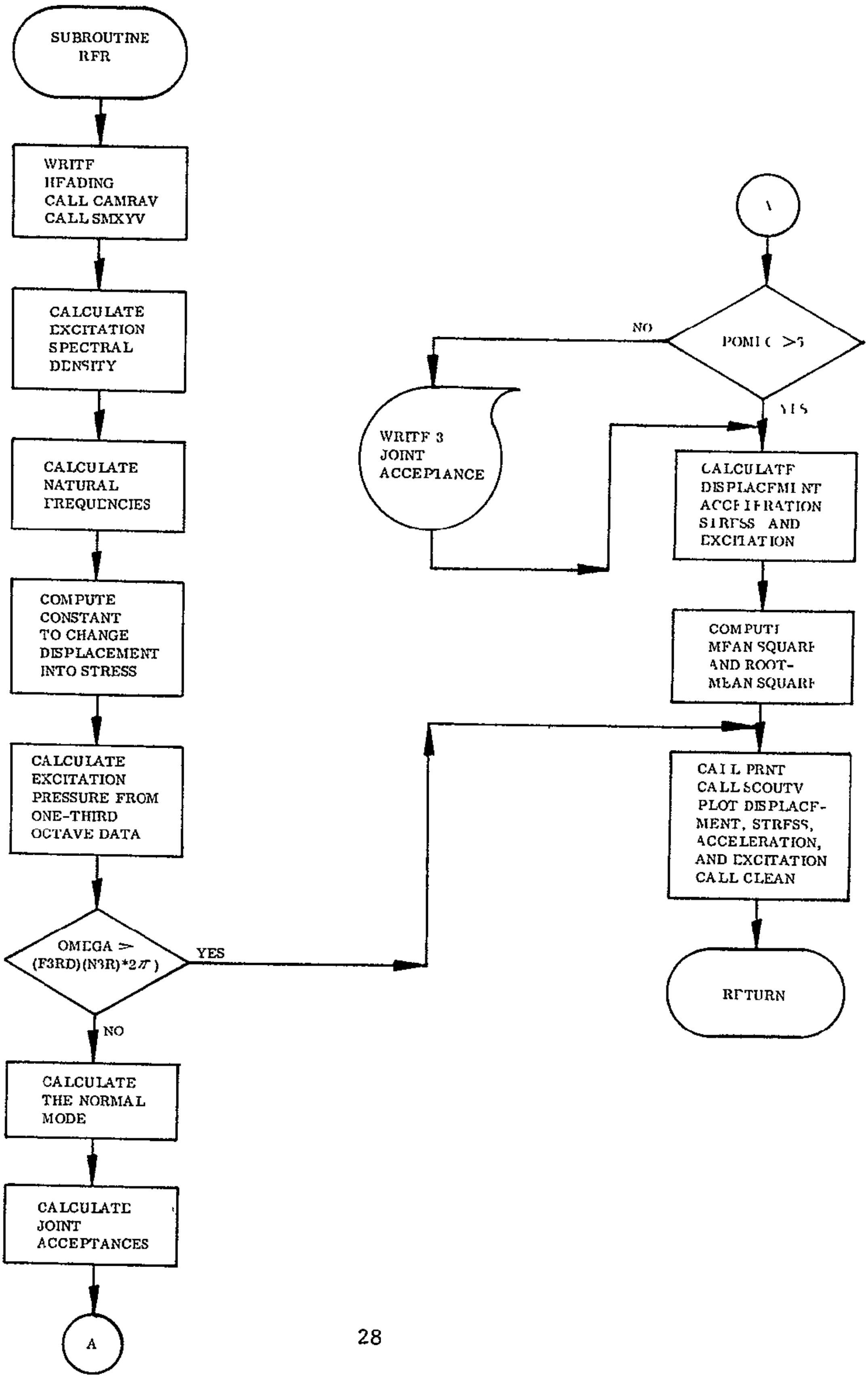
b. SUBROUTINE GRIDIV



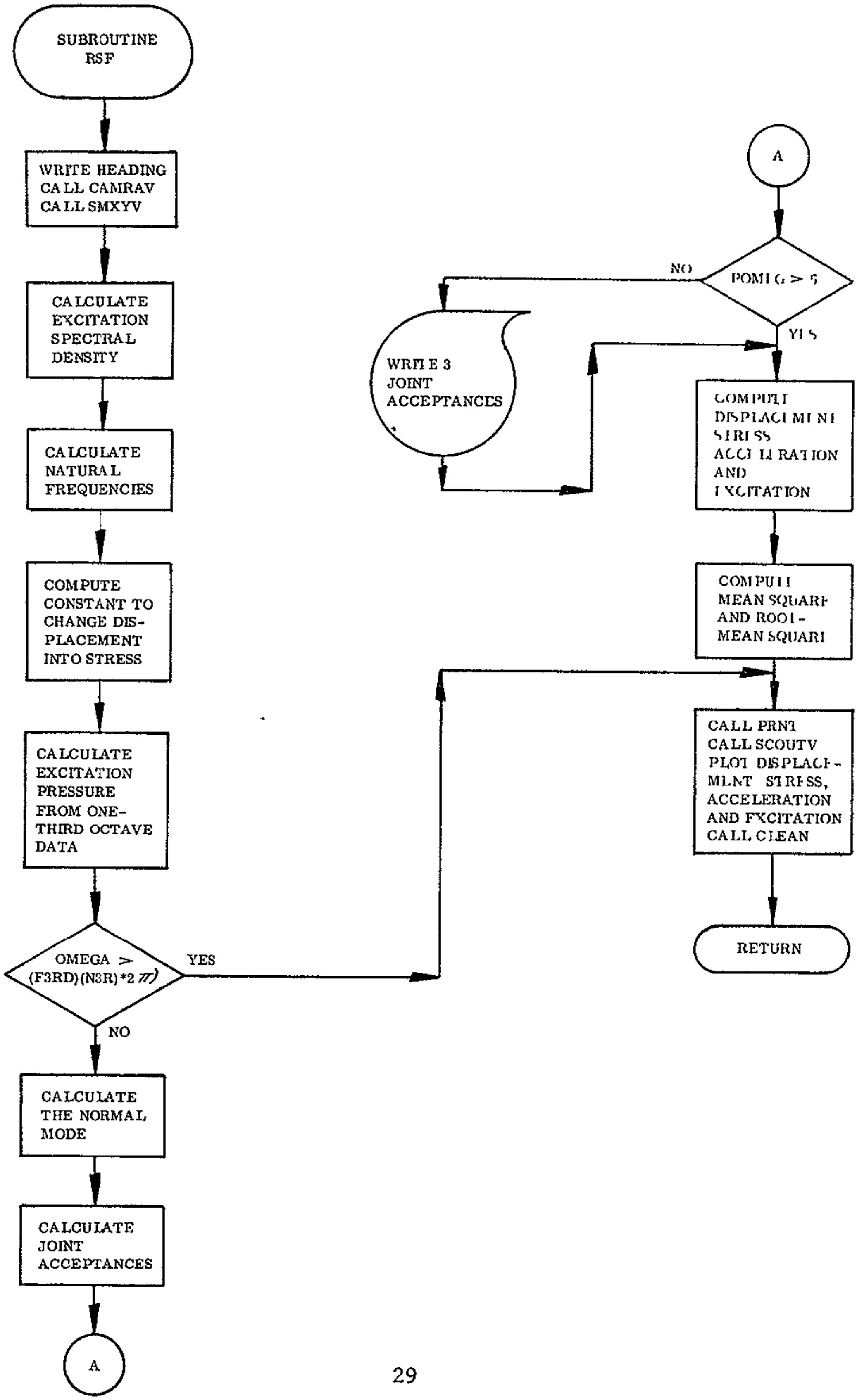
c. SUBROUTINE RSR



d. SUBROUTINE RFR

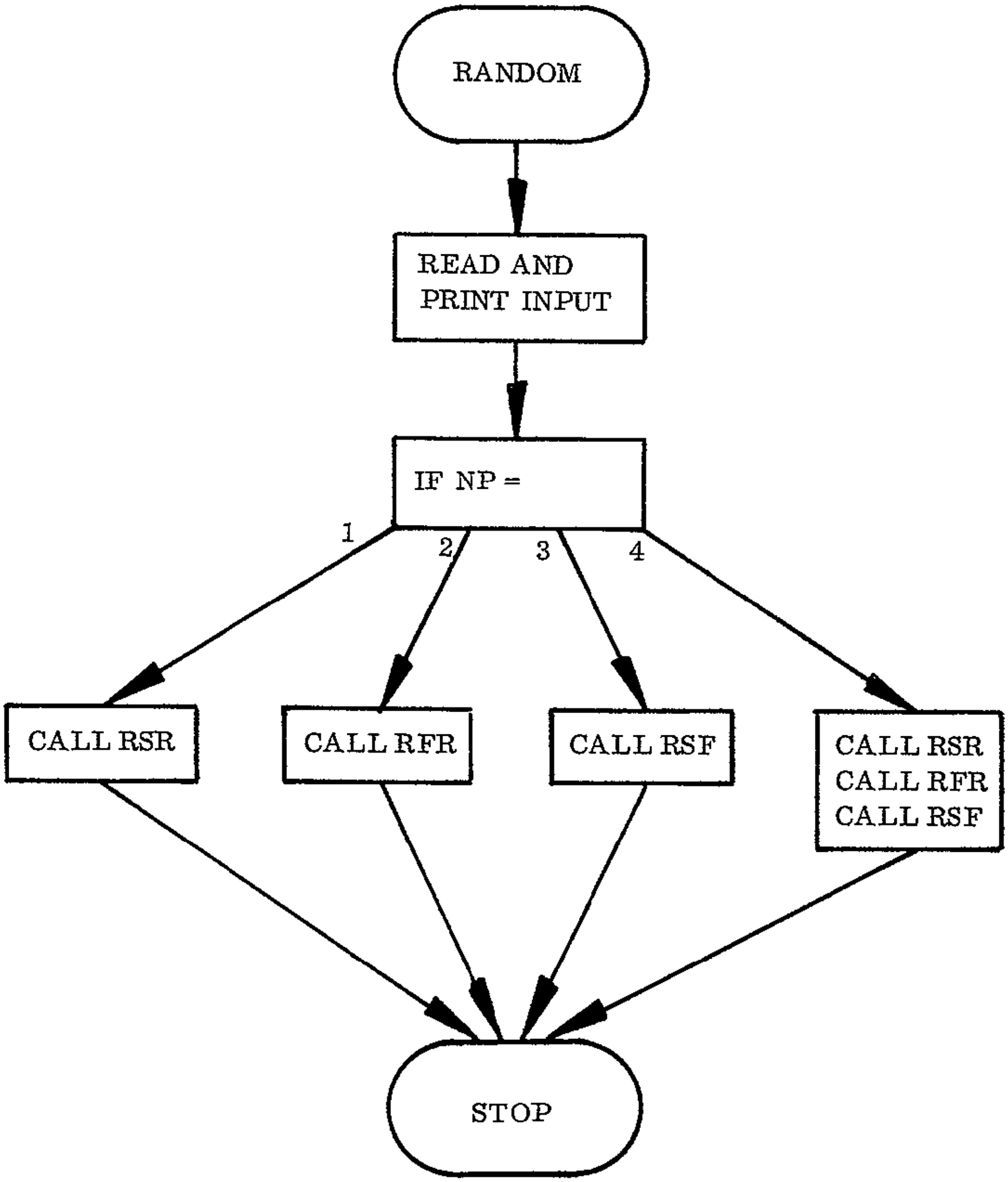


e. SUBROUTINE RSF

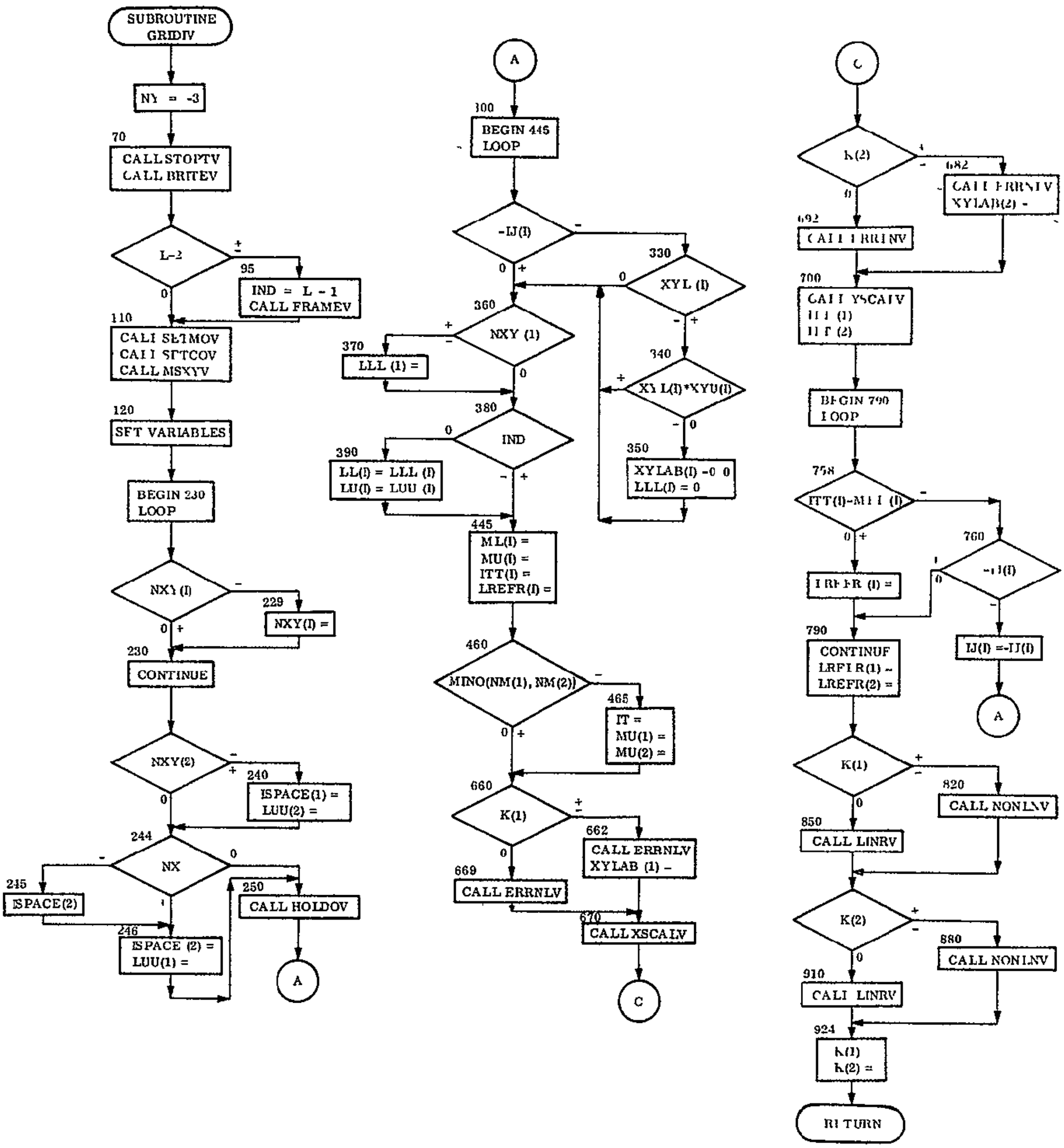


G. FLOW CHARTS

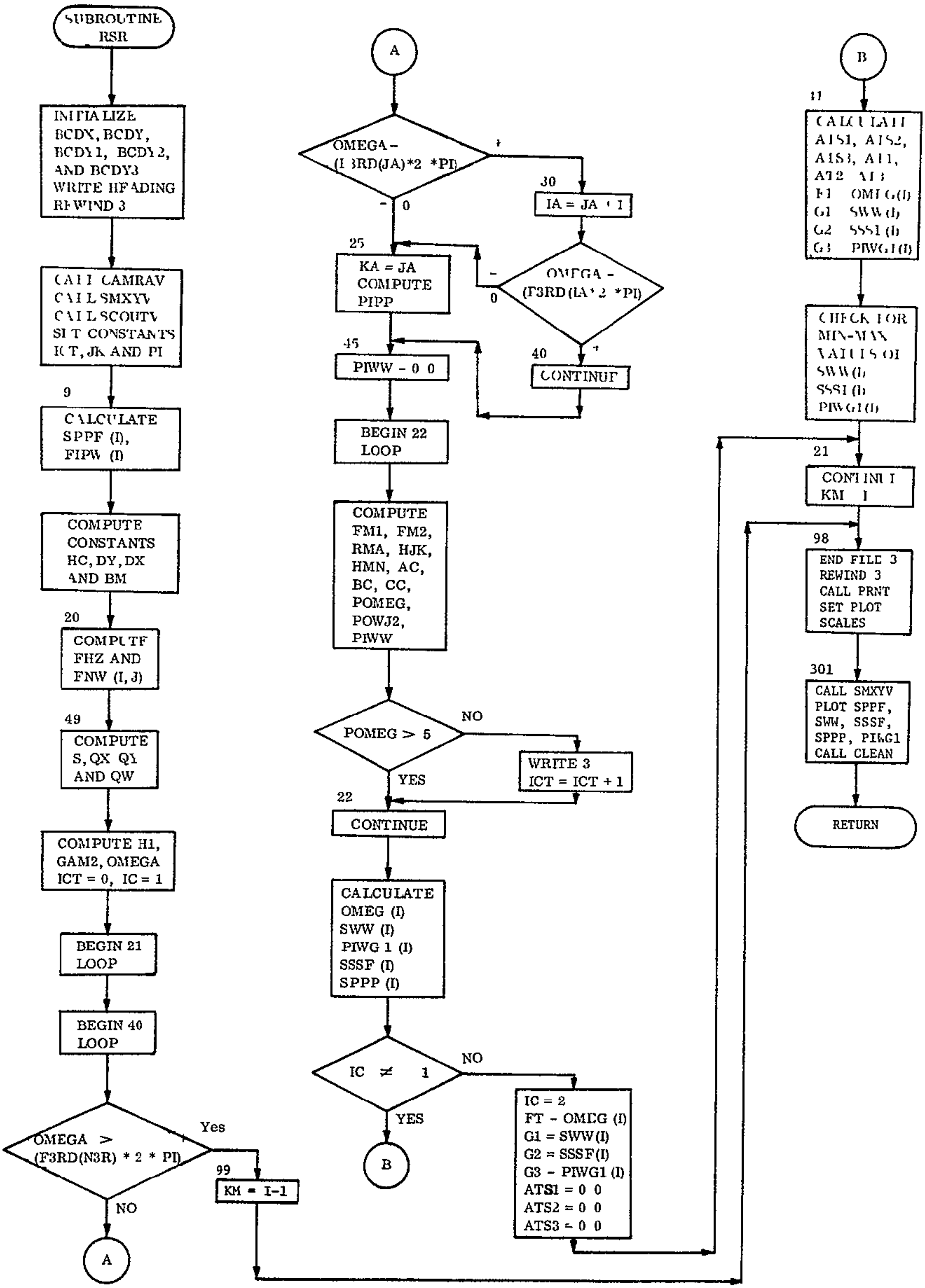
a PROGRAM RANDOM



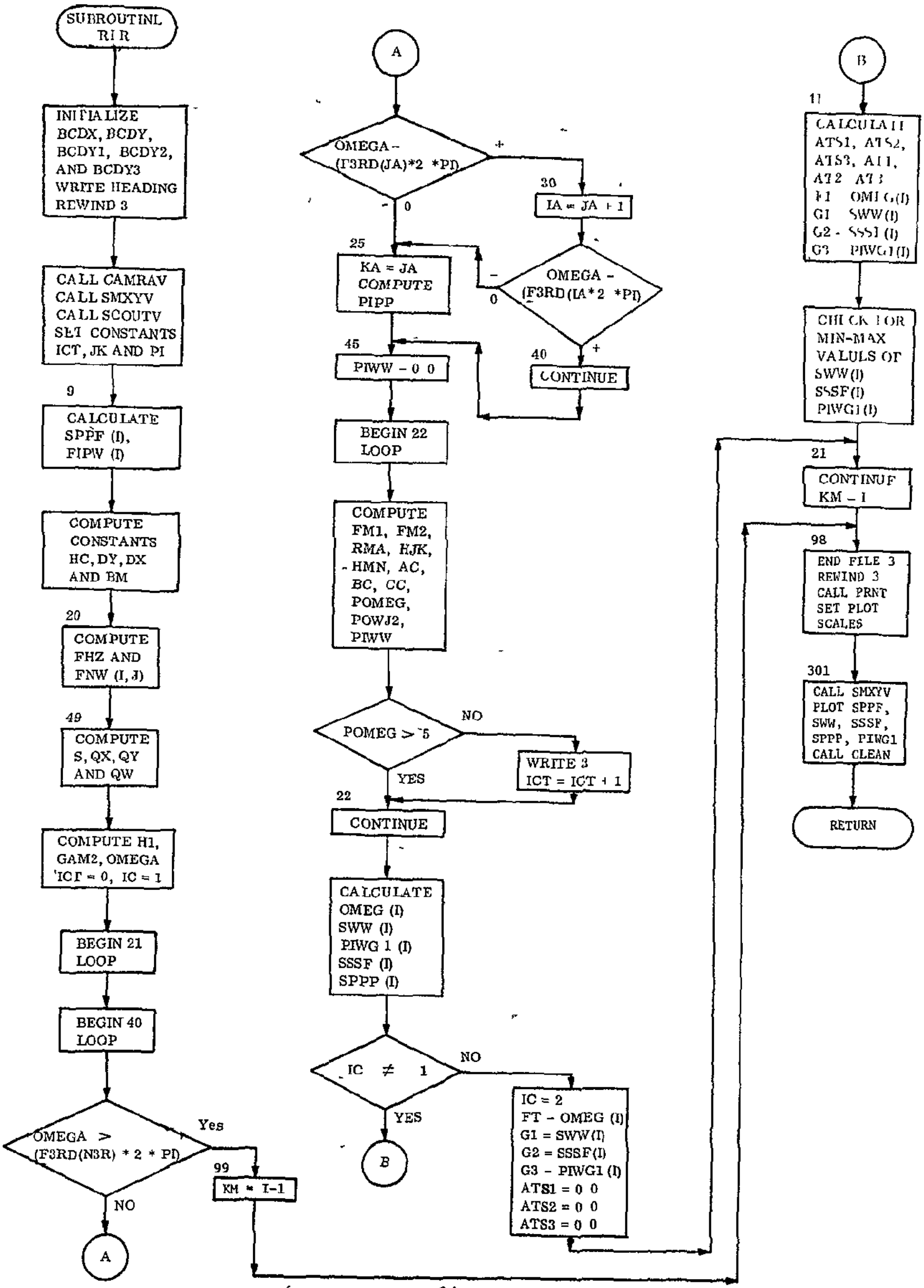
b. SUBROUTINE GRIDV



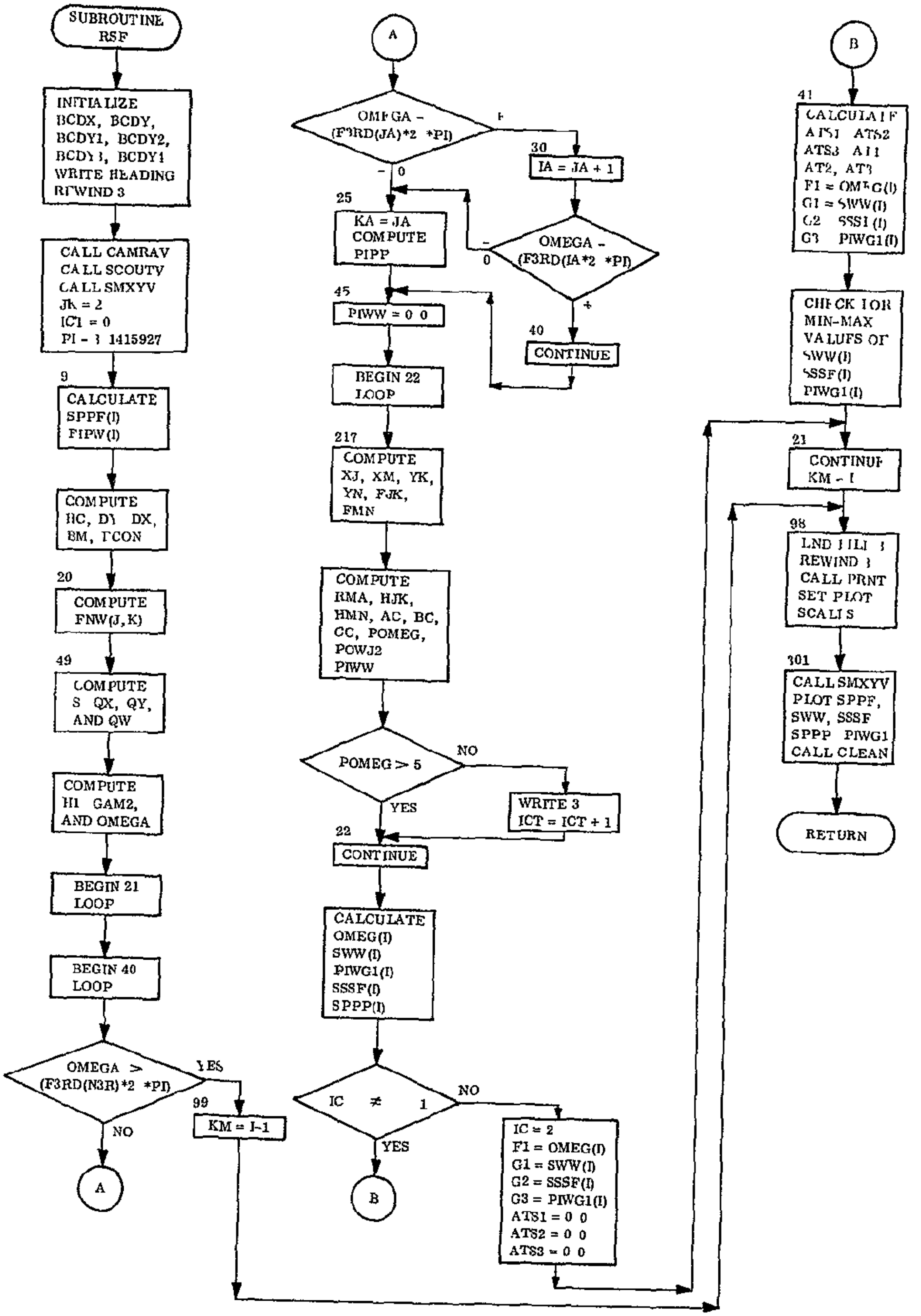
c. SUBROUTINE RSR



d. SUBROUTINE RFR



e. SUBROUTINE RSF



H. PROGRAM LISTING

```
$IBFTC RAND
C     PROGRAM  R A N D O M
C     COMPUTER PROGRAM FOR PREDICTION OF STRUCTURAL VIBRATIONS
C     DUE TO FLUCTUATING PRESSURE ENVIRONMENTS, COMBINATION
C     OF PROGRAMS RSRPC1, RFRPC1, AND RSFRP1.  RECTANGULAR
C     CYLINDRICAL SHELL PANEL CROSS-REINFORCED WITH RIBS AND
C     STRINGERS,  BOUNDARY CONDITIONS - FOUR EDGES SIMPLY-SUPPORTED,
C     FOUR EDGES CLAMPED, TWO OPPOSITE EDGES SIMPLY-SUPPORTED
C     WHILE OTHER CLAMPED.  INPUT EXCITATION SPECTRAL DENSITY
C     AND OUTPUT DISPLACEMENT, STRESS AND ACCELERATION SPECTRAL
C     DENSITIES ARE PLOTTED IN GRAPHIC FORMS.
C     DEVELOPED BY CHRYSLER HUNTSVILLE OPERATIONS, UNDER MSFC
C     CONTRACT NAS8-21403.
      DIMENSION FNW(10,10),F3RD(40),S3RD(40),SPPP(400)
      DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400)
      DIMENSION           SWW(400),SSSF(400)
      COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
     1A2,F,EP,VIP,AL1,BL1,AI1,AI2,H2,HP,RAD,RHOP,RLA
      COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
     1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
     2QX,QY,QW,GAM2,IRD
C     READ AND PRINT INPUT DATA
      READ (5,133) NP,N3R
      READ(5,5)PL,B,RHO,HS
      READ(5,5)CI,X,Y,FINN
      READ (5,5) A1,C,PLP,BP
      READ (5,5) A2,E,EP,VIP
      READ (5,5) AL1,BL1,AI1,AI2
      READ (5,5) H2,HP,RAD,RHOP
      READ (5,8)(F3RD(I),S3RD(I),I=1,N3R)
      WRITE (6,103) PL,B,RHO,HS,CI,X,Y,FINN,A1,C
      WRITE (6,132) PLP,BP,A2,E,EP,VIP,AL1,BL1,AI1,AI2,H2,HP,RAD,RHOP
      GO TO (200,201,202,200),NP
C     CALCULATING RESPONSES OF FOUR EDGES SIMPLY-SUPPORTED PANEL
  200 CALL RSR
      IF (NP .NE. 4) GO TO 99
C     CALCULATING RESPONSES OF FOUR EDGES CLAMPED PANEL
  201 CALL RFR
      IF (NP .NE. 4) GO TO 99
C     CALCULATING RESPONSES OF TWO OPPOSITE EDGES SIMPLY-SUPPORTED
C     WHILE OTHER TWO CLAMPED PANEL
  202 CALL RSF
   99 STOP
5     FORMAT(4F15.8)
8     FORMAT(8F8.1)
  103 FORMAT(1H1,10X,16HINPUT DATA       ,//,
     120H PL = PANEL LENGTH =,E12.5,/,
     218H B = PANEL WIDTH =,E12.5,/,
     330H RHO = MASS DENSITY OF PANEL =,E12.5,/,
     423H HS = PANEL THICKNESS =,E12,5,/,
     521H CI = DAMPING RATIO =,E12.5,/,
     629H X = COORDINATE OF VECTOR R =,E12.5,/,
     729H Y = COORDINATE OF VECTOR R =,E12,5,/,
     862H FINN = ONE NTH OCTAVE FREQUENCY INCREMENT  =
     9,E12.5,/,34H A1 = DECAYING CONSTANT - LENGTH =  E12.5,/,
```

```
     $21H C = SPEED OF SOUND = E12.5)
 132 FORMAT(48H PLP = LENGTH OF PANEL SUBJECTED TO EXCITATION =E12.5,/,
     146H BP = WIDTH OF PANEL SUBJECTED TO EXCITATION =E12.5,/,
     233H A2 = DECAYING CONSTANT - WIDTH =E12.5,/,
     330H E = YOUNGS MODULUS OF PANEL =E12.5,/,
     436H EP = YOUNGS MODULUS OF STIFFENERS =E12.5,/,
     523H VIP = POISSONS RATIO =E12.5,/,
     644H AL1 = SPACING OF Y - DIRECTION STIFFENERS =E12.5,/,
     744H BL1 = SPACING OF X - DIRECTION STIFFENERS =E12.5,/,
     857H AI1 = MOMENT OF INERTIA OF ONE Y - DIRECTION STIFFENER =E12.5,
     9/,57H AI2 = MOMENT OF INERTIA OF ONE X - DIRECTION STIFFENER =
     $E12.5,/,48H H2 = LARGEST HEIGHT OF STIFFENERS AT VECTOR R =E12.5,
     $/,43H HP = SMEARED-OUT THICKNESS OF STIFFENERS =E12.5,/,
     $24H RAD = RADIUS OF SHELL =E12.5,/,
     $36H RHOP = MASS DENSITY OF STIFFENERS =E12.5,///)
 133 FORMAT(4I5)
      END
$IBFTC PNT
      SUBROUTINE PRNT
      DIMENSION FNW(10,10),F3RD(40),S3RD(40),SPPP(400)
      DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400)
      DIMENSION              SWW(400),SSSF(400)
      COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
     1A2,E,EP,VIP,AL1,BL1,AI1,AI2,H2,HP,RAD,RHOP,RLA
      COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
     1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
     2QX,QY,QW,GAM2,IRD
      PI=3.1415927
      WRITE (6,110)
      DO 200 I=1,N3R
 200  WRITE (6,115) F3RD(I),S3RD(I),SPPF(I),FIPW(I)
      WRITE (6,100)
      DO 201 J=1,9
      DO 201 K=1,9
      FHZ = FNW(J,K)/(2.*PI)
 201  WRITE (6,120) J,K,FHZ     ,FNW(J,K)
      WRITE (6,125)
 206  WRITE (6,130)  ( OMEG(I),SWW(I),SSSF(I),PIWG1(I),SPPP(I),I=1,KM)
 207  IF (JK .EQ. 2) GO TO 203
      WRITE (6,102) ATS1,ATS2,ATS3
      WRITE (6,101)       AT1,AT2,AT3
      WRITE (6,131) QX,QY,QW,GAM2,FINN
      GO TO 204
 203  WRITE (6,102) ATS1,ATS2,ATS3,PAS
      PA=SQRT(PAS)
      WRITE (6,101)       AT1,AT2,AT3,PA
      WRITE (6,131) QX,QY,QW,GAM2,FINN
 204  WRITE (6,105)
      IF (ICT .EQ. 0) GO TO 208
      DO 202 I=1,ICT
      READ (3)      POMEG  ,J,K,M,N,POWJ2
 202  WRITE (6,104) POMEG  ,J,K,M,N,POWJ2
      REWIND 3
 208  WRITE (6,50)
      RETURN
```

```
50      FORMAT(12H1END OF DATA)
100     FORMAT(1H1,    36H       NATURAL FREQUENCIES              //,2X4HJ  K,1
       10X3HFHZ,20X3HFNW/16X2HHZ,18X7HRAD/SEC//)
  101 FORMAT(13H     RMS VALUE ,4E16.8,/)
  102 FORMAT(/,13H     MS  VALUE ,4E16.8,/)
  104 FORMAT(F12.5,4I3,3E15.8)
  105 FORMAT(11H1 FREQUENCY,5X,4HMODE,5X,16HJOINT ACCEPTANCE,/,
       14X,5HHERTZ,6X,7HINDICES,8X,6HSQUARE,/,14X,10HJ  K  M  N,/)
  107 FORMAT(11X,30HOVERALL MEAN-SQUARE PRESSURE =,E15.7)
110     FORMAT(///,38X16HINPUT EXCITATION//8X14HONE-3RD OCTAVE,7X20HONE-3R
       1D OCTAVE LEVEL,7X16HSPECTRAL DENSITY,7X16HSPECTRAL DENSITY/8X14HME
       2AN FREQUENCY,12X11HIN DECIBELS,11X17HIN DECIBELS/HERTZ,6X17HIN PSI
       3 SQ/RAD/SEC/14X4HF3RD,19X4HS3RD,22X4HSPPF,20X4HFIPW//)
115     FORMAT(F20.3,3XF20.3,6XF20.3,6XE20.5)
120     FORMAT(2I3, F15.5,7X,F15.5)
  125 FORMAT(13H1    FREQUENCY,3X,12HDISPLACEMENT,7X,6HSTRESS,7X,
       112HACCELERATION,5X,10HEXCITATION,/,18X,8HRESPONSE,4X,
       216H     RESPONSE     ,4X,8HRESPONSE,
       3/,6X,5HHERTZ,3X,16H INCH SQ/HERTZ  ,2X,12HPSI SQ/HERTZ,5X,10HG SQ/
       4HERTZ,4X,14HPSI SQ/RAD/SEC,/)
  130 FORMAT(1X,F12.5,4E16.8)
  131 FORMAT(/,5H QX =E12.5,2X,4HQY =F12.5,2X,4HQW =E12.5,2X,8HGAMMA2 =
       1E12.5,/,8H  FINN =,F5.1/)
        END
$IBFTC GRID
        SUBROUTINE GRID1V (L,XL,XU,YL,YU,DX,DY,NN,MM,II,JJ,NX,NY)
C       GENERAL GRID SUBROUTINE FOR SC4020 --- LINEAR OR NONLINEAR  IN -
C       EITHER VERTICAL OR HORIZONTAL
        DIMENSION XYL(2),XYU(2),DXY(2),NM(2),IJ(2),NXY(2),XYLAB(2), LREFR(
       12),K(2),LLL(2),LUU(2),LL(2),LU(2),MTL(2),MTU(2),ML(2),MU(2),ITT(2)
       2,ISPACE(2),ITOP(2)
        EQUIVALENCE  (ITOP(1),MUH) ,(ITOP(2),MUV)
C       STOP TYPE--MAY NOT NEED
        NY=-3
   70 CALL STOPTV
        CALL BRITEV
        IF(L-2) 95,110,95
   95 IND=L-1
  100 CALL FRAMEV(IND)
  110 CALL SETMOV (MTL(1),MTU(1),MTL(2),MTU(2))
        CALL SETCOV (IWIDE,IHIGH)
        CALL MSXYV (K(1),K(2))
  120 XYL(1)=XL
        XYL(2)=YL
        XYU(1)=XU
        XYU(2)=YU
        DXY(1)=DX
        DXY(2)=DY
        NM(1)=NN
        NM(2)=MM
        IJ(1)=II
        IJ(2)=JJ
        NXY(1)=NX
        NXY(2)=NY
        DO 230  I= 1,2
```

```
      ISPACE(I)=0
      LUU(I)=0
      IF(NXY(I)) 229,230,230
  229 NXY(I)=7-NXY(I)
  230 CONTINUE
      IF(NXY(2))240,244,240
  240 ISPACE(1)=NXY(2)*IWIDE+IWIDE+6
      LUU(2)=IHIGH+6
  244 IF(NX) 245,250,246
  245 ISPACE(2)=IHIGH/2
  246 ISPACE(2)=ISPACE(2)+IHIGH+6
      LUU(1)=(NXY(1)*IWIDE)/2
  250 CALL HOLDOV(IND)
C     COMPUTE LABEL MARGINS,IF IND IS  ZERO
  300 DO 445  I=1,2
      LLL(I)=ISPACE(I)
      XYLAB(I)=XYL(I)
      IF(-IJ(I)) 330,360,360
  330 IF(XYL(I)) 340,360,340
  340 IF(XYL(I)*XYU(I)) 350,350,360
  350 XYLAB(I)=0.0
  355 LLL(I)=0
  360 IF(NXY(1)) 370,380,370
  370 LLL(1)=MAX0(LUU(1)+IWIDE+2,LLL(1))
  380 IF(IND) 420, 390,420
  390 LL(I)=LLL(I)
      LU(I)=LUU(I)
  420 ML(I)=LL(I)+MTL(I)
      MU(I)=LU(I)+MTU(I)
  440 ITT(I)=ML(I)+MU(I)
  445 LREFR(I)=MTL(I)+3
C     END OF LOOP FROM 300
  460 IF (MIN0(NM(1),NM(2)))465,660,660
  465 IT=MAX0(ITT(1),ITT(2))
  480 MU(1)=IT-ML(1)
      MU(2)=IT-ML(2)
C     ERROR TESTS AND SCALE
  660 IF(K(1))662,669,662
  662 CALL ERRNLV(XYL(1),XYU(1),ML(1),MU(1),DXY(1))
      XYLAB(1)=XYL(1)
      GO TO 670
  669 CALL ERRLNV(XYL(1),XYU(1),ML(1),MU(1),DXY(1))
  670 CALL XSCALV (XYL(1),XYU(1),ML(1),MU(1) )
      IF (K(2)) 682,692,682
  682 CALL ERRNLV (XYL(2),XYU(2),ML(2),MU(2),DXY(2))
      XYLAB(2)=XYL(2)
      GO TO 700
  692 CALL ERRLNV (XYL(2),XYU(2),ML(2),MU(2),DXY(2))
  700 CALL YSCALV (XYL(2),XYU(2),ML(2),MU(2))
      ITT(1)=NXV(XYLAB(1))-ISPACE(1)
      ITT(2)=NYV(XYLAB(2))-ISPACE(2)
      DO 790  I=1,2
      ITOP(I)=1023-MU(I)
  758 IF(ITT(I)-MTL(I))760,780,780
  760 IF(-IJ(I)) 770,790,790
```

```
  770 IJ(I)=-IJ(I)
      GO TO 300
  780 LREFR(I)=ITT(I)+2
  790 CONTINUE
  805 LREFR(1)=LREFR(1)+IWIDE+IWIDE/2
      LREFR(2)=LREFR(2)+IHIGH/2
  810 IF(K(1)) 820,850,820
  820 CALL NONLNV(1,LREFR(2),ML(2),MUV,XYL(1),XYU(1),DXY(1), NM(1),IJ(1)
     1,NX,IWIDE)
      GO TO 870
  850 CALL LINRV(1,LREFR(2),ML(2),MUV,XYL(1),XYU(1),DXY(1),NM(1),IJ(1),
     1NX,IWIDE)
  870 IF(K(2)) 880,910,880
  880 CALL NONLNV(2,LREFR(1),ML(1),MUH,XYL(2),XYU(2),DXY(2),NM(2),IJ(2)
     1,NY,IHIGH)
  900 GO TO 924
  910 CALL LINRV(2,LREFR(1),ML(1),MUH,XYL(2),XYU(2),DXY(2),NM(2),IJ(2),
     1NY,IHIGH)
C     TO CLEAR ERROR INDICATOR --IF GRID DATA IN ERROR ,ERROR INDICATORS
C    1MIGHT NOT BE CLEARED
  924 K(1)=NXV(XYL(1))
      K(2)=NYV(XYL(2))
  930 RETURN
      END
$ORIGIN        A
$IBFTC RSR1
      SUBROUTINE RSR
C     PROGRAM NUMBER 823-1002-6
C     RSRPC1
C     CALCULATION OF RESPONSE OF SIMPLY SUPPORTED RECTANGULAR PANELS
C     CROSS-REINFORCED WITH STIFFENERS
C     INPUT PARAMETERS
C     PL = PANEL LENGTH
C     B = PANEL WIDTH
C     RHO = MASS DENSITY OF PANEL
C     HS = PANEL THICKNESS
C     CI = DAMPING RATIO
C     X = COORDINATE OF VECTOR R
C     Y = COORDINATE OF VECTOR R
C     FINN = ONE NTH OCTAVE FREQUENCY INCREMENT
C     A = CONSTANT
C     C = SPEED OF SOUND
C     PLP = LENGTH OF PANEL UNDER EXCITATION
C     BP  = WIDTH  OF PANEL UNDER EXCITATION
C     F3RD = ONE-THIRD OCTAVE BAND CENTER FREQUENCY
C     S3RD = SOUND PRESSURE LEVEL
      DIMENSION FNW(10,10),F3RD(40),S3RD(40),BCDX(12),BCDY(12)
      DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400),BCDY1(12)
      DIMENSION BCDY2(12),SWW(400),SSSF(400),BCDY3(12)
      DIMENSION SPPP(400)
      COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
     1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
     2QX,QY,QW,GAM2,IRD
      COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
     1A2,E,EP,VIP,AL1,BL1,AI1,AI2,H2,HP,RAD,RHOP,RLA
```

```
      DATA BCDX/72HFREQUENCY (HZ)
     1                        /
      DATA BCDY/72HACCELERATION G SQ/HZ
     1                        /
      DATA BCDY2/72HDISPLACEMENT  INCH SQ/HERTZ
     1                        /
      DATA BCDY3/72HSTRESS SPECTRAL DENSITY  PSI SQ/HERTZ
     1                        /
      DATA BCDY1/72HSPPF  DB/HZ
     1                        /
      WRITE (6,108)
      ICK=1
 1001 REWIND 3
      JK=1
      PI=3.1415927
      SWMI= 1.E10
      SWMX= 1.E-10
      SSMI= 1.E10
      SSMX= 1.E-10
      PIMI= 1.E10
      PIMX= 1.E-10
      CALL CAMRAV(9)
      CALL SMXYV(1,0)
C     CALCULATE EXCITATION SPECTRAL DENSITY
      DO 9 I=1,N3R
      SPPF(I)=S3RD(I)-10.*ALOG10(0.2315*F3RD(I))
      FIPW(I)=1./(2.0*PI)*10.0**((SPPF(I)-170.576)/10.0)
9     CONTINUE
C     CALCULATE NATURAL FREQUENCIES
      HC=F*HS*HS*HS/(12.*(1.-VIP*VIP))
      DY=HC+EP*AI2/AL1
      DX=HC+EP*AI1/BL1
      BM = RHO*HS+RHOP*HP
      DO 20 I=1,9
      DO 20 J=1,9
      RM=I
      RN=J
      FHZ=DX*(RM   /PL)**4+2.*HC*(RM*RN/(PL*B))**2+DY*(RN/B)**4
     1+E*HS/(RAD*RAD*(PI)**4*(1.+(PL*RN/(B*RM))**2)**2)
      FNW(I,J)=PI*PI*SQRT( 1./BM)*SQRT(FHZ)
20    CONTINUE
C     CALCULATE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS
      QX=0.0
      QY=0.0
      QW=0.0
      S=BP*PLP
      DO 49 IJ=1,5,2
      DO 49 IK=1,5,2
      RM=IJ
      RN=IK
      FSIN=SIN(RM*PI*X/PL)*SIN(RN*PI*Y/B)
      QCON=RM*RN*(DX*(RM/PL)**4+2.*HC*(RM*RN/(PL*B))**2+DY*(RN/B)**4)
      QX=QX+((RM*PI/PL)**2+VIP*(RN*PI/B)**2)*(FSIN/QCON)
      QY=QY+((RN*PI/B)**2+VIP*(RM*PI/PL)**2)*(FSIN/QCON)
   49 QW=QW+FSIN/QCON
```

```
      H1=HS+H2
      GAM2=E*H1*H1*E/(4.*(1.-VIP*VIP)**2)*((QX*QX+QY*QY)/(QW*QW))
C     CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA
1000  CON=  2.0**(1.0/FINN)
      OMEGA=F3RD(1)*2.0*PI
      ICT=0
      IC=1
      DO 21 I=1,400
      N3R1=N3R-1
      DO 40 JA=1,N3R1
      IF ( OMEGA .GT. (F3RD(N3R)*2.*PI)) GO TO 99
      IF(OMEGA-(F3RD(JA)*2.*PI))25,25,30
25    KA=JA
      GO TO 35
30    IA=JA+1
      IF(OMEGA-(F3RD(IA)*2.*PI))25,25,40
35    PIPP=FIPW(KA)+(FIPW(KA+1)-FIPW(KA))*(OMEGA-F3RD(KA)*2.*PI)/((F3RD
     1(KA+1)-F3RD(KA))*2.*PI)
      GO TO 45
40    CONTINUE
   45 PIWW=0.0
      DO 22 J=1,5
      DO 22 K=1,5
      DO 22 M=1,5
      DO 22 N=1,5
      RK=K
      RN=N
      RJ=J
      RM=M
      FM1=SIN(RJ*PI*X/PL)*SIN(RK*PI*Y/B)
      FM2=SIN(RM*PI*X/PL)*SIN(RN*PI*Y/B)
      RMA=RHO*HS*B*PL/4.0
      HJK=ABS(1./(RMA*SQRT((FNW(J,K)*FNW(J,K)-OMEGA*OMEGA)**2
     1+(2.*CI*FNW(J,K)*OMEGA)**2)))
      HMN=ABS(1./(RMA*SQRT((FNW(M,N)*FNW(M,N)-OMEGA*OMEGA)**2
     1+(2.*CI*FNW(M,N)*OMEGA)**2)))
C     CALCULATE JOINT ACCEPTANCES
      AC=(1.-(OMEGA/FNW(J,K))**2)*(1.-(OMEGA/FNW(M,N))**2)+4.*CI*CI*OMEG
     1A**2/(FNW(J,K)*FNW(M,N))
      BC=-2.*((CI*OMEGA/FNW(J,K))*(1.-(OMEGA/FNW(M,N))**2)-CI*OMEGA/
     1FNW(M,N)*(1.-(OMEGA/FNW(J,K))**2))
      CC=AC*AC+BC*BC
      CON1=(A1*OMEGA*PL/C)*(A1*OMEGA*PL/C)
      CON2=RJ*PI
      CON3=RM*PI
      CON6=CON2*CON3*((2.+EXP(-A1*PL*OMEGA/C)*((-1.)**(J+1)+((-1.)**
     1(M+1))))/((CON1+CON2*CON2)*(CON1+CON3*CON3)))
      CON7=RK*PI
      CON8=RN*PI
      IF (J .NE. M) GO TO 46
      PJJM =  (A1*PL*OMEGA/C/2.*(1./(CON1+CON2*CON2)+
     11./(CON1+CON3*CON3))+CON6)
      GO TO 47
   46 PJJM  =  CON6+RM   /(CON1+CON3*CON3)*(((-1.)**(J-M)-1.)/(2.*
     1(RJ-RM))+((-1.)**(J+M)-1.)/(2.*(RJ+RM)))
```

```
     2   +RJ    /(CON1+CON2*CON2)*(((-1.)**(M-J)-1.)/(2.*(RM-RJ))
     3+((-1.)**(M+J)-1.)/(2.*(RM+RJ)))
  47 CON1=(A2*OMEGA*B /C)*(A2*OMEGA*B /C)
      CON6=CON7*CON8*((2.+EXP(-A2*B *OMEGA/C)*((-1.)**(K+1)+((-1.)**
     1(N+1))))/((CON1+CON7*CON7)*(CON1+CON8*CON8)))
      IF(K .NE. N) GO TO 48
      PJKN =  (A2*PL*OMEGA/C/2.*(1./(CON1+CON7*CON7)+
     11./(CON1+CON8*CON8))+CON6)
      GO TO 23
  48 PJKN  =  CON6+RN    /(CON1+CON8*CON8)*(((-1.)**(K-N)-1.)/(2.*
     1(RK-RN))+((-1.)**(K+N)-1.)/(2.*(RK+RN)))
     2   +RK    /(CON1+CON7*CON7)*(((-1.)**(N-K)-1.)/(2.*(RN-RK))
     3+((-1.)**(N+K)-1.)/(2.*(RN+RK)))
  23 POMEG=OMEGA/(2.*PI)
      POWJ2=PJJM*PJKN*AC/SQRT(CC)
      PIWW=PIWW+FM1*FM2*HJK*HMN*POWJ2
      IF (POMEG .GT. 5.) GO TO 22
      WRITE (3)       POMEG   ,J,K,M,N,POWJ2
      ICT=ICT+1
  22 CONTINUE
      OMEG(I)=OMEGA/(2.*PI)
C     CALCULATE DISPLACEMENT, STRESS,AND ACCELERATION
      PIWW=PIWW*S*S*PIPP
      SWW(I)=PIWW*2.*PI
      PIWG    =OMEGA**4*PIWW
      PIWG1(I)=4.215093E-05*PIWG
      PSSW=GAM2*PIWW
      SSSF(I)=2.*PI*PSSW
      SPPP(I)=2.*PI*PIPP
C     CALCULATE MEAN SQUARE
      IF ( IC .NE. 1 ) GO TO 41
      F1=OMEG(I)
      G1=SWW(I)
      G2=SSSF(I)
      G3=PIWG1(I)
      ATS1=0.0
      ATS2=0.0
      ATS3=0.0
      IC=2
      GO TO 21
  41  ATS1=ATS1+(G1+SWW(I))/2.*(OMEG(I)-F1)
      ATS2=ATS2+(G2+SSSF(I))/2.*(OMEG(I)-F1)
      ATS3=ATS3+(G3+PIWG1(I))/2.*(OMEG(I)-F1)
C     CALCULATE ROOT-MEAN SQUARE
      F1=OMEG(I)
      G1=SWW(I)
      G2=SSSF(I)
      G3=PIWG1(I)
      IF(SWW(I) .LT. SWMI ) SWMI=SWW(I)
      IF(SWW(I) .GT. SWMX) SWMX=SWW(I)
      IF(SSSF(I) .LT. SSMI)SSMI=SSSF(I)
      IF(SSSF(I) .GT. SSMX)SSMX=SSSF(I)
      IF(PIWG1(I) .LT. PIMI) PIMI=PIWG1(I)
      IF(PIWG1(I) .GT. PIMX) PIMX=PIWG1(I)
      OMEGA=        OMEGA* CON
```

```
21     CONTINUE
       KM=I
       GO TO 98
   99  KM=I-1
   98  END FILE 3
       REWIND 3
       AT1=SQRT(ATS1)
       AT2=SQRT(ATS2)
       AT3=SQRT(ATS3)
       CALL PRNT
       DSW = SWMX/1.E9
       DSS = SSMX/1.E9
       DPI = PIMX/1.E9
       DO 301 I=1,KM
       IF(SWW(I) .LT. DSW) SWW(I)=DSW
       IF(SSSF(I) .LT. DSS) SSSF(I)=DSS
       IF(PIWG1(I) .LT. DPI) PIWG1(I)=DPI
  301  CONTINUE
C      PLOT EXCITATION, DISPLACEMENT, STRESS, AND ACCELERATION
       CALL QUIK3V(-1,44,BCDX,BCDY1,-N3R,F3RD,SPPF)
       CALL SCOUTV
       CALL SMXYV(1,1)
       CALL QUIK3V(-1,44,BCDX,BCDY2,-KM,OMEG,SWW)
       WRITE (16,106) AT1,FINN
       CALL QUIK3V(-1,44,BCDX,BCDY3,-KM,OMEG,SSSF)
       WRITE (16,106) AT2,FINN
       CALL QUIK3V(-1,44,BCDX,BCDY,-KM,OMEG,PIWG1)
       WRITE (16,106) AT3,FINN
       CALL CLEAN
  106  FORMAT(11X,31H    ROOT-MEAN-SQUARE RESPONSE =    E15.7,5X,6HFINN =
      1F6.2,10X,6HRSRPC1 )
  108  FORMAT(96H1CALCULATION OF RESPONSE OF SIMPLY SUPPORTED RECTANGULAR
      1 PANELS CROSS-REINFORCED WITH STIFFENERS)
       RETURN
       END
$ORIGIN        A
$IBFTC RFR1
       SUBROUTINE RFR
C      PROGRAM NUMBER 823-1002-7
C      RFRPC1
C      DYNAMIC RESPONSE OF FOUR-SIDE FIXED RECTANGULAR
C      SHELL PANELS CROSS-REINFORCED WITH STIFFENERS
C      INPUT PARAMETERS
C      PL = PANEL LENGTH
C      B = PANEL WIDTH
C      RHO = MASS DENSITY OF PANEL
C      HS = PANEL THICKNESS
C      CI = DAMPING RATIO
C      X = COORDINATE OF VECTOR R
C      Y = COORDINATE OF VECTOR R
C      FINN = CONSTANT TO DETERMINE OCTAVE BAND CENTER FREQUENCIES
C      A1 = CONSTANT
C      C = SPEED OF SOUND
C      BP = LENGTH OF PANEL UNDER EXCITATION
C      PLP = WIDTH  OF PANEL UNDER EXCITATION
```

```
C     F3RD = ONE-THIRD OCTAVE BAND CENTER FREQUENCY
C     S3RD = SOUND PRESSURE LEVEL
      DIMENSION FNW(10,10),F3RD(40),S3RD(40),BCDX(12),BCDY(12)
      DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400),BCDY1(12)
      DIMENSION BCDY2(12),SWW(400),SSSF(400),BCDY3(12),BCDY4(12)
      DIMENSION SPPP(400)
      COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
     1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
     2QX,QY,QW,GAM2,IRD
      COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
     1A2,F,EP,VIP,AL1,BL1,AI1,AI2,H2,HP,RAD,RHOP,RLA
      DATA BCDX/72HFREQUENCY (HZ)
     1              /
      DATA BCDY/72HACCELERATION G SQ/HZ
     1              /
      DATA BCDY2/72HDISPLACEMENT  INCH SQ/HERTZ
     1              /
      DATA BCDY3/72HSTRESS SPECTRAL DENSITY  PSI SQ/HERTZ
     1              /
      DATA BCDY1/72HSPPF  DB/HZ
     1              /
      DATA BCDY4/72HSPECTRAL DENSITY  PSI SQ/HERTZ
     1              /
      WRITE (6,108)
      REWIND 3
      JK=2
      ICT=0
      PI=3.1415927
      SWMI= 1.E10
      SWMX= 1.E-10
      SSMI= 1.E10
      SSMX= 1.E-10
      PIMI= 1.E10
      PIMX= 1.E-10
      CALL CAMRAV(9)
      CALL SMXYV(1,0)
C     EQUATIONS 11 AND 12
C     CALCULATE EXCITATION SPECTRAL DENSITY
      DO 9 I=1,N3R
      SPPF(I)=S3RD(I)-10.*ALOG10(0.2315*F3RD(I))
      FIPW(I)=1./(2.0*PI)*10.0**((SPPF(I)-170.576)/10.0)
9     CONTINUE
C     CALCULATE NATURAL FREQUENCIES
C     EQUATIONS 1 AND 2
      HC=E*HS*HS*HS/(12.*(1.-VIP*VIP))
      DY=HC+EP*AI2/AL1
      DX=HC+EP*AI1/BL1
      BM = RHO*HS+RHOP*HP
      FCON = PI*PI/SQRT(BM)
      DO 20 J=1,9
      DO 20 K=1,9
      RJ = J
      RK = K
      IF(J .NE. 1 .AND. K .NE. 1) GO TO 18
      IF(J .EQ. 1 .AND. K .NE. 1) GO TO 16
```

```
      IF(J .NE. 1 .AND. K .EQ. 1) GO TO 17
      FHZ = DX*(1.5056/PL)**4+DY*(1.5056/B)**4+2.*HC*(1.2466/(PL*B))**2
     1+E*HS/(RAD*RAD*(PI)**4*(1.+(PL/B)*(PL/B))**2)
      GO TO 19
   16 FHZ = DX*(1.5056/PL)**4+DY*((RK+.5)/B)**4
     1+2.*HC*((1.2466*(RK+.5)*((RK+.5)-.6366))/(PL*PL*B*B))
     2+E*HS/(RAD*RAD*(PI)**4*(1.+((RK+.5)/1.5056)**2*(PL/B)*(PL/B))**2)
      GO TO 19
   17 FHZ = DX*((RJ+.5)/PL)**4+DY*(1.5056/B )**4
     1+2.*HC*(1.2466*(RJ+.5)*((RJ+.5)-.6366)/(PL*PL*B*B))
     2+E*HS/(RAD*RAD*(PI)**4*(1.+(1.5056/(RJ+.5))**2*(PL/B)*(PL/B))**2)
      GO TO 19
   18 FHZ = DX*((RJ+.5)/PL)**4+DY*((RK+.5)/B)**4
     1+2.*HC*((RJ+.5)*(RK+.5)*((RJ+.5)-.6366)*((RK+.5)-.6366)/(PL*PL*B*B
     2))+E*HS/(RAD*RAD*(PI)**4*(1.+((RK+.5)/(RJ+.5))**2
     3*(PL/B)*(PL/B))**2)
   19 FNW(J,K) = FCON*SQRT(FHZ)
   20 CONTINUE
C     CALCULATE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS
C     EQUATION 16
      QX=0.0
      QY=0.0
      QW=0.0
      S=BP*PLP
      DO 49 IJ=1,5,2
      DO 49 IK=1,5,2
      RM=IJ
      RN=IK
      FSIN=SIN(RM*PI*X/PL)*SIN(RN*PI*Y/B)
      QCON=RM*RN*(DX*(RM/PL)**4+2.*HC*(RM*RN/(PL*B))**2+DY*(RN/B)**4)
      QX=QX+((RM*PI/PL)**2+VIP*(RN*PI/B)**2)*(FSIN/QCON)
      QY=QY+((RN*PI/B)**2+VIP*(RM*PI/PL)**2)*(FSIN/QCON)
   49 QW=QW+FSIN /QCON
      H1=HS+H2
      GAM2=E*H1*H1*E/(4.*(1.-VIP*VIP)**2)*((QX*QX+QY*QY)/(QW*QW))
C     CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA
1000  CON=  2.0**(1.0/FINN)
      OMEGA=F3RD(1)*2.0*PI
      IC=1
      DO 21 I=1,400
      N3R1=N3R-1
      DO 40 JA=1,N3R1
      IF ( OMEGA .GT. (F3RD(N3R)*2.*PI)) GO TO 99
      IF(OMEGA-(F3RD(JA)*2.*PI))25,25,30
25    KA=JA
      GO TO 35
30    IA=JA+1
      IF(OMEGA-(F3RD(IA)*2.*PI))25,25,40
35    PIPP=FIPW(KA)+(FIPW(KA+1)-FIPW(KA))*(OMEGA-F3RD(KA)*2.*PI)/((F3RD
     1(KA+1)-F3RD(KA))*2.*PI)
      GO TO 45
40    CONTINUE
   45 PIWW=0.0
      DO 22 J=1,5
      DO 22 K=1,5
```

```
      DO 22 M=1,5
      DO 22 N=1,5
      RJ=J
      RK=K
      RM=M
      RN=N
C     CALCULATE THE NORMAL MODE
C     EQUATION 4
      CX1 = 1.5056*PI*X/PL
      CY1 = 1.5056*PI*Y/B
      CXJ = (RJ+.5)*PI*X/PL
      CXM = (RM+.5)*PI*X/PL
      CYK = (RK+.5)*PI*Y/B
      CYN = (RN+.5)*PI*Y/B
      CHX1 = (EXP(CX1)+EXP(-CX1))/2.
      SHX1 = (EXP(CX1)-EXP(-CX1))/2.
      CHY1 = (EXP(CY1)+EXP(-CY1))/2.
      SHY1 = (EXP(CY1)-EXP(-CY1))/2.
      CHXJ = (EXP(CXJ)+EXP(-CXJ))/2.
      SHXJ = (EXP(CXJ)-EXP(-CXJ))/2.
      CHXM = (EXP(CXM)+EXP(-CXM))/2.
      SHXM = (EXP(CXM)-EXP(-CXM))/2.
      CHYK = (EXP(CYK)+EXP(-CYK))/2.
      SHYK = (EXP(CYK)-EXP(-CYK))/2.
      CHYN = (EXP(CYN)+EXP(-CYN))/2.
      SHYN = (EXP(CYN)-EXP(-CYN))/2.
      IF(J .GT. 1) GO TO 210
      XJ = CHX1-COS(CX1)-.9825*(SHX1-SIN(CX1))
      GO TO 211
  210 XJ = CHXJ - COS(CXJ)-(SHXJ-SIN(CXJ))
  211 IF (K .GT. 1) GO TO 212
      YK = CHY1-COS(CY1)-.9825*(SHY1-SIN(CY1))
      GO TO 213
  212 YK = CHYK-COS(CYK)-(SHYK-SIN(CYK))
  213 IF(M .GT. 1) GO TO 214
      XM = CHX1-COS(CX1)-.9825*(SHX1-SIN(CX1))
      GO TO 215
  214 XM = CHXM-COS(CXM)-(SHXM-SIN(CXM))
  215 IF(N .GT. 1) GO TO 216
      YN = CHY1-COS(CY1)-.9825*(SHY1-SIN(CY1))
      GO TO 217
  216 YN = CHYN-COS(CYN)-(SHYN-SIN(CYN))
  217 FJK = XJ*YK
      FMN = XM*YN
C     EQUATION 5
      RMA=RHO*HS*B*PL/4.0
C     EQUATION 6
      HJK=ABS(1./(RMA*SQRT((FNW(J,K)*FNW(J,K)-OMEGA*OMEGA)**2
     1+(2.*CI*FNW(J,K)*OMEGA)**2)))
      HMN=ABS(1./(RMA*SQRT((FNW(M,N)*FNW(M,N)-OMEGA*OMEGA)**2
     1+(2.*CI*FNW(M,N)*OMEGA)**2)))
C     CALCULATE JOINT ACCEPTANCES
C     EQUATION 7
      AC=(1.-(OMEGA/FNW(J,K))**2)*(1.-(OMEGA/FNW(M,N))**2)+4.*CI*CI*OMEG
     1A**2/(FNW(J,K)*FNW(M,N))
```

```
      BC=-2.*((CI*OMEGA/FNW(J,K))*(1.-(OMEGA/FNW(M,N))**2)-CI*OMEGA/
     1FNW(M,N)*(1.-(OMEGA/FNW(J,K))**2))
      CC=AC*AC+BC*BC
      CON1=(A1*OMEGA*PL/C)*(A1*OMEGA*PL/C)
      CON2=RJ*PI
      CON3=RM*PI
      CON6=CON2*CON3*((2.+EXP(-A1*PL*OMEGA/C)*((-1.)**(J+1)+((-1.)**
     1(M+1))))/((CON1+CON2*CON2)*(CON1+CON3*CON3)))
      CON7=RK*PI
      CON8=RN*PI
      IF (J .NE. M) GO TO 46
      PJJM =  (A1*PL*OMEGA/C/2.*(1./(CON1+CON2*CON2)+
     11./(CON1+CON3*CON3))+CON6)
      GO TO 47
   46 PJJM  =  CON6+RM   /(CON1+CON3*CON3)*(((-1.)**(J-M)-1.)/(2.*
     1(RJ-RM))+((-1.)**(J+M)-1.)/(2.*(RJ+RM)))
     2  +RJ   /(CON1+CON2*CON2)*(((-1.)**(M-J)-1.)/(2.*(RM-RJ))
     3+((-1.)**(M+J)-1.)/(2.*(RM+RJ)))
   47 CON1=(A2*OMEGA*B /C)*(A2*OMEGA*B /C)
      CON6=CON7*CON8*((2.+EXP(-A2*B *OMEGA/C)*((-1.)**(K+1)+((-1.)**
     1(N+1))))/((CON1+CON7*CON7)*(CON1+CON8*CON8)))
      IF(K .NE. N) GO TO 48
      PJKN =  (A2*B *OMEGA/C/2.*(1./(CON1+CON7*CON7)+
     11./(CON1+CON8*CON8))+CON6)
      GO TO 23
   48 PJKN  =  CON6+RN   /(CON1+CON8*CON8)*(((-1.)**(K-N)-1.)/(2.*
     1(RK-RN))+((-1.)**(K+N)-1.)/(2.*(RK+RN)))
     2  +RK   /(CON1+CON7*CON7)*(((-1.)**(N-K)-1.)/(2.*(RN-RK))
     3+((-1.)**(N+K)-1.)/(2.*(RN+RK)))
   23 POMEG=OMEGA/(2.*PI)
      POWJ2=PJJM*PJKN*AC/SQRT(CC)
      PIWW=PIWW+FJK*FMN*HJK*HMN*POWJ2
      IF (POMEG .GT. 5.) GO TO 22
      WRITE (3)      POMEG  ,J,K,M,N,POWJ2
      ICT=ICT+1
   22 CONTINUE
      OMEG(I)=OMEGA/(2.*PI)
C     CALCULATE DISPLACEMENT, STRESS,AND ACCELERATION
C     EQUATIONS 8, 13, 14, 16,AND 17
      PIWW=PIWW*S*S*PIPP
      SWW(I)=PIWW*2.*PI
      PIWG   =OMEGA**4*PIWW
      PIWG1(I)=4.215093E-05*PIWG
      PSSW=GAM2*PIWW
      SSSF(I)=2.*PI*PSSW
C     EQUATION 12A
      SPPP(I)=2.*PI*PIPP
      IF ( IC .NE. 1 ) GO TO 41
C     MEAN SQUARE EQUATIONS
      F1=OMEG(I)
      G1=SWW(I)
      G2=SSSF(I)
      G3=PIWG1(I)
      G4=SPPP(I)
      ATS1=0.0
```

```
      ATS2=0.0
      ATS3=0.0
      ATS4=0.0
      IC=2
      GO TO 21
   41 ATS1=ATS1+(G1+SWW(I))/2.*(OMEG(I)-F1)
      ATS2=ATS2+(G2+SSSF(I))/2.*(OMEG(I)-F1)
      ATS3=ATS3+(G3+PIWG1(I))/2.*(OMEG(I)-F1)
      ATS4=ATS4+(G4+SPPP (I))/2.*(OMEG(I)-F1)
C     ROOT-MEAN SQUARE EQUATIONS
      F1=OMEG(I)
      G1=SWW(I)
      G2=SSSF(I)
      G3=PIWG1(I)
      G4=SPPP(I)
      IF(SWW(I) .LT. SWMI ) SWMI=SWW(I)
      IF(SWW(I) .GT. SWMX) SWMX=SWW(I)
      IF(SSSF(I) .LT. SSMI)SSMI=SSSF(I)
      IF(SSSF(I) .GT. SSMX)SSMX=SSSF(I)
      IF(PIWG1(I) .LT. PIMI) PIMI=PIWG1(I)
      IF(PIWG1(I) .GT. PIMX) PIMX=PIWG1(I)
      DSW = SWMX/1.E9
      DSS = SSMX/1.E9
      DPI = PIMX/1.E9
      OMEGA=       OMEGA* CON
21    CONTINUE
      KM=I
      GO TO 98
   99 KM=I-1
C     EQUATION 12B
   98 PAS=ATS4
      AT1=SQRT(ATS1)
      AT2=SQRT(ATS2)
      AT3=SQRT(ATS3)
      AT4=SQRT(ATS4)
      PA=AT4
      RLA=170.576+10.*ALOG10(PAS)
      END FILE 3
      REWIND 3
      CALL PRNT
      IF(DSW .LE. SWMI) GO TO 302
      DO 301 I=1,KM
      IF(SWW(I) .LT. DSW) SWW(I)=DSW
  301 CONTINUE
  302 IF(DSS .LE. SSMI) GO TO 304
      DO 303 I=1,KM
      IF(SSSF(I) .LT. DSS) SSSF(I)=DSS
  303 CONTINUE
  304 IF(DPI .LE. PIMI) GO TO 306
      DO 305 I=1,KM
      IF(PIWG1(I) .LT. DPI) PIWG1(I)=DPI
  305 CONTINUE
C     PLOT EXCITATION, DISPLACEMENT, STRESS, AND ACCELERATION
  306 CALL SCOUTV
      CALL QUIK3V(-1,44,BCDX,BCDY1,-N3R,F3RD,SPPF)
```

```
      WRITE (16,109)RLA
      CALL SMXYV(1,1)
      CALL QUIK3V(-1,44,BCDX,BCDY2,-KM,OMEG,SWW)
      WRITE (16,106) AT1,FINN
      CALL QUIK3V(-1,44,BCDX,BCDY3,-KM,OMEG,SSSF)
      WRITE (16,106) AT2,FINN
      CALL QUIK3V(-1,44,BCDX,BCDY,-KM,OMEG,PIWG1)
      WRITE (16,106) AT3,FINN
      CALL QUIK3V(-1,44,BCDX,BCDY4,-KM,OMEG,SPPP)
      WRITE (16,107) PA
      CALL CLEAN
  106 FORMAT(11X,31H    ROOT-MEAN-SQUARE RESPONSE =    E15.7,5X,6HFINN =
     1F6.2,10X,6HRFRPC1 )
  107 FORMAT(11X,30H   ROOT-MEAN-SQUARE PRESSURE =,E15.7)
  108 FORMAT(94H1DYNAMIC RESPONSE OF FOUR-SIDE FIXED RECTANGULAR SHELL P
     1ANELS CROSS-REINFORCED WITH STIFFENERS)
  109 FORMAT(11X,24HOVERALL PRESSURE LEVEL = E15.7,8HDECIBELS)
      RETURN
      END
$ORIGIN        A
$IBFTC RSF1
      SUBROUTINE RSF
C     PROGRAM NUMBER 823-1002-7A
C     RSFRP1
C     DYNAMIC RESPONSE OF TWO-OPPOSITE-SIDE SIMPLY-SUPPORTED
C     AND OTHER TWO SIDES FIXED RECTANGULAR SHELL PANELS
C     UNDER RANDOM PRESSURE FIELD
C     INPUT PARAMETERS
C     PL = PANEL LENGTH
C     B = PANEL WIDTH
C     RHO = MASS DENSITY OF PANEL
C     HS = PANEL THICKNESS
C     CI = DAMPING RATIO
C     X = COORDINATE OF VECTOR R
C     Y = COORDINATE OF VECTOR R
C     FINN = CONSTANT TO DETERMINE OCTAVE BAND CENTER FREQUENCIES
C     A1 = CONSTANT
C     C = SPEED OF SOUND
C     BP = LENGTH OF PANEL UNDER EXCITATION
C     PLP = WIDTH  OF PANEL UNDER EXCITATION
C     F3RD = ONE-THIRD OCTAVE BAND CENTER FREQUENCY
C     S3RD = SOUND PRESSURE LEVEL
      DIMENSION FNW(10,10),F3RD(40),S3RD(40),BCDX(12),BCDY(12)
      DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400),BCDY1(12)
      DIMENSION BCDY2(12),SWW(400),SSSF(400),BCDY3(12),BCDY4(12)
      DIMENSION SPPP(400)
      COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
     1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
     2QX,QY,QW,GAM2,IRD
      COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
     1A2,E,EP,VIP,AL1,BL1,AI1,AI2,H2,HP,RAD,RHOP,RLA
      DATA BCDX/72HFREQUENCY (HZ)
     1                  /
      DATA BCDY/72HACCELERATION G SQ/HZ
     1                  /
```

```
      DATA BCDY2/72HDISPLACEMENT  INCH SQ/HERTZ
     1                     /
      DATA BCDY3/72HSTRESS SPECTRAL DENSITY  PSI SQ/HERTZ
     1                     /
      DATA BCDY1/72HSPPF   DB/HZ
     1                     /
      DATA BCDY4/72HSPECTRAL DENSITY  PSI SQ/HERTZ
     1                     /
      WRITE (6,108)
      SWMI= 1.E10
      SWMX= 1.E-10
      SSMI= 1.E10
      SSMX= 1.E-10
      PIMI= 1.E10
      PIMX= 1.E-10
      REWIND 3
      JK=2
      ICT=0
      PI=3.1415927
      CALL CAMRAV(9)
      CALL SMXYV(1,0)
C     CALCULATE EXCITATION SPECTRAL DENSITY
C     EQUATIONS 11 AND 12
      DO 9 I=1,N3R
      SPPF(I)=S3RD(I)-10.*ALOG10(0.2315*F3RD(I))
      FIPW(I)=1./(2.0*PI)*10.0**((SPPF(I)-170.576)/10.0)
9     CONTINUE
C     CALCULATE NATURAL FREQUENCIES
C     EQUATIONS 1 AND 2
      HC=E*HS*HS*HS/(12.*(1.-VIP*VIP))
      DY=HC+EP*AI2/AL1
      DX=HC+EP*AI1/BL1
      BM = RHO*HS+RHOP*HP
      FCON = PI*PI/SQRT(BM)
      DO 20 J=1,9
      DO 20 K=1,9
      RJ = J
      RK = K
      IF(J .NE. 1 .AND. K .NE. 1) GO TO 18
      IF(J .EQ. 1 .AND. K .NE. 1) GO TO 16
      IF(J .NE. 1 .AND. K .EQ. 1) GO TO 17
      FHZ = DX*(1.     /PL)**4+DY*(1.5056/B)**4+2.*HC*(1./PL)*(1./PL)*
     1(1.1165/B)*(1.1165/B)+E*HS/(RAD*RAD*(PI)**4*(1.+(1./1.5056)*(1./
     21.5056)*(PL/B)*(PL/B))**2)
      GO TO 19
   16 FHZ = DX*(1.     /PL)**4+DY*((RK+.5)/B)**4
     1+2.*HC*(1./PL)**2*(((RK+.5)*((RK+.5)-.6366))/(B*B))
     2+E*HS/(RAD*RAD*(PI)**4*(1.+(1./(RK+.5))     **2*(PL/B)*(PL/B))**2)
      GO TO 19
   17 FHZ = DX*( RJ    /PL)**4+DY*(1.5056/B )**4
     1+2.*HC*(RJ/PL)*(RJ/PL)*(1.1165/B)*(1.1165/B)
     2+E*HS/(RAD*RAD*(PI)**4*(1.+(RJ/1.5056      )**2*(PL/B)*(PL/B))**2)
      GO TO 19
   18 FHZ = DX*( RJ    /PL)**4+DY*((RK+.5)/B)**4
     1+2.*HC*( RJ/PL)*(RJ/PL)*((RK+.5)*((RK+.5)-.6366))/(B*B)
```

```
      2 +E*HS/(RAD*RAD*(PI)**4*(1.+( RJ    /(RK+.5))**2
      3*(PL/B)*(PL/B))**2)
   19 FNW(J,K) = FCON*SQRT(FHZ)
   20 CONTINUE
C     CALCULATE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS
C     EQUATION 16
      QX=0.0
      QY=0.0
      QW=0.0
      S=BP*PLP
      DO 49 IJ=1,5,2
      DO 49 IK=1,5,2
      RM=IJ
      RN=IK
      FSIN=SIN(RM*PI*X/PL)*SIN(RN*PI*Y/B)
      QCON=RM*RN*(DX*(RM/PL)**4+2.*HC*(RM*RN/(PL*B))**2+DY*(RN/B)**4)
      QX=QX+((RM*PI/PL)**2+VIP*(RN*PI/B)**2)*(FSIN/QCON)
      QY=QY+((RN*PI/B)**2+VIP*(RM*PI/PL)**2)*(FSIN/QCON)
   49 QW=QW+FSIN /QCON
      H1=HS+H2
      GAM2=F*H1*H1*E/(4.*(1.-VIP*VIP)**2)*((QX*QX+QY*QY)/(QW*QW))
C     CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA
1000  CON=  2.0**(1.0/FINN)
      OMEGA=F3RD(1)*2.0*PI
      IC=1
      DO 21 I=1,400
      N3R1=N3R-1
      DO 40 JA=1,N3R1
      IF ( OMEGA .GT. (F3RD(N3R)*2.*PI)) GO TO 99
      IF(OMEGA-(F3RD(JA)*2.*PI))25,25,30
25    KA=JA
      GO TO 35
30    IA=JA+1
      IF(OMEGA-(F3RD(IA)*2.*PI))25,25,40
35    PIPP=FIPW(KA)+(FIPW(KA+1)-FIPW(KA))*(OMEGA-F3RD(KA)*2.*PI)/((F3RD
     1(KA+1)-F3RD(KA))*2.*PI)
      GO TO 45
40    CONTINUE
   45 PIWW=0.0
      PIWWI=0.0
C     EQUATION 3
      DO 22 J=1,5
      DO 22 K=1,5
      DO 22 M=1,5
      DO 22 N=1,5
      RJ=J
      RK=K
      RM=M
      RN=N
C     CALCULATE THE NORMAL MODE
C     EQUATION 4
      XJ=SIN(RJ*PI*X/PL)
      XM=SIN(RM*PI*X/PL)
      CY1 = 1.5056*PI*Y/B
      CYK = (RK+.5)*PI*Y/B
```

```
      CYN = (RN+.5)*PI*Y/B
      CHY1 = (EXP(CY1)+EXP(-CY1))/2.
      SHY1 = (EXP(CY1)-EXP(-CY1))/2.
      CHYK = (EXP(CYK)+EXP(-CYK))/2.
      SHYK = (EXP(CYK)-EXP(-CYK))/2.
      CHYN = (EXP(CYN)+EXP(-CYN))/2.
      SHYN = (EXP(CYN)-EXP(-CYN))/2.
  211 IF (K .GT. 1) GO TO 212
      YK = CHY1-COS(CY1)-.9825*(SHY1-SIN(CY1))
      GO TO 215
  212 YK = CHYK-COS(CYK)-(SHYK-SIN(CYK))
  215 IF(N .GT. 1) GO TO 216
      YN = CHY1-COS(CY1)-.9825*(SHY1-SIN(CY1))
      GO TO 217
  216 YN = CHYN-COS(CYN)-(SHYN-SIN(CYN))
  217 FJK = XJ*YK
      FMN = XM*YN
C     EQUATION 5
      RMA=RHO*HS*B*PL/4.0
C     EQUATION 6
      HJK=ABS(1./(RMA*SQRT((FNW(J,K)*FNW(J,K)-OMEGA*OMEGA)**2
     1+(2.*CI*FNW(J,K)*OMEGA)**2)))
      HMN=ABS(1./(RMA*SQRT((FNW(M,N)*FNW(M,N)-OMEGA*OMEGA)**2
     1+(2.*CI*FNW(M,N)*OMEGA)**2)))
C     CALCULATE JOINT ACCFPTANCES
C     EQUATION 7
      AC=(1.-(OMEGA/FNW(J,K))**2)*(1.-(OMEGA/FNW(M,N))**2)+4.*CI*CI*OMEG
     1A**2/(FNW(J,K)*FNW(M,N))
      BC=-2.*((CI*OMEGA/FNW(J,K))*(1.-(OMEGA/FNW(M,N))**2)-CI*OMEGA/
     1FNW(M,N)*(1.-(OMEGA/FNW(J,K))**2))
      CC=AC*AC+BC*BC
      CON1=(A1*OMFGA*PL/C)*(A1*OMFGA*PL/C)
      CON2=RJ*PI
      CON3=RM*PI
      CON6=CON2*CON3*((2.*EXP(-A1*PL*OMEGA/C)*((-1.)**(J+1)+((-1.)**
     1(M+1))))/((CON1+CON2*CON2)*(CON1+CON3*CON3)))
      CON7=RK*PI
      CON8=RN*PI
      IF (J .NE. M) GO TO 46
      PJJM =  (A1*PL*OMEGA/C/2.*(1./(CON1+CON2*CON2)+
     11./(CON1+CON3*CON3))+CON6)
      GO TO 47
   46 PJJM  =  CON6+RM   /(CON1+CON3*CON3)*(((-1.)**(J-M)-1.)/(2.*
     1(RJ-RM))+((-1.)**(J+M)-1.)/(2.*(RJ+RM)))
     2  +RJ   /(CON1+CON2*CON2)*(((-1.)**(M-J)-1.)/(2.*(RM-RJ))
     3+((-1.)**(M+J)-1.)/(2.*(RM+RJ)))
   47 CON1=(A2*OMEGA*B /C)*(A2*OMEGA*B /C)
      CON6=CON7*CON8*((2.*EXP(-A2*B *OMEGA/C)*((-1.)**(K+1)+((-1.)**
     1(N+1))))/((CON1+CON7*CON7)*(CON1+CON8*CON8)))
      IF(K .NE. N) GO TO 48
      PJKN =  (A2*B *OMEGA/C/2.*(1./(CON1+CON7*CON7)+
     11./(CON1+CON8*CON8))+CON6)
      GO TO 23
   48 PJKN  =  CON6+RN   /(CON1+CON8*CON8)*(((-1.)**(K-N)-1.)/(2.*
     1(RK-RN))+((-1.)**(K+N)-1.)/(2.*(RK+RN)))
```

```
  2  +RK    /(CON1+CON7*CON7)*(((-1.)**(N-K)-1.)/(2.*(RN-RK))
  3+((-1.)**(N+K)-1.)/(2.*(RN+RK)))
 23 POMEG=OMEGA/(2.*PI)
    POWJ2=PJJM*PJKN*AC/SQRT(CC)
    PIWW=PIWW+FJK*FMN*HJK*HMN*POWJ2
    IF (POMEG .GT. 5.) GO TO 22
    WRITE (3)      POMEG  ,J,K,M,N,POWJ2
    ICT=ICT+1
 22 CONTINUE
    OMEG(I)=OMEGA/(2.*PI)
C   CALCULATE DISPLACEMENT, STRESS,AND ACCELERATION
C   EQUATIONS 8, 13, 14, 16,AND 17
    PIWW=PIWW*S*S*PIPP
    SWW(I)=PIWW*2.*PI
    PIWG   =OMEGA**4*PIWW
    PIWG1(I)=4.215093E-05*PIWG
    PSSW=GAM2*PIWW
    SSSF(I)=2.*PI*PSSW
    SPPP(I)=2.*PI*PIPP
    IF ( IC .NE. 1 ) GO TO 41
C   MEAN SQUARE EQUATIONS
    F1=OMEG(I)
    G1=SWW(I)
    G2=SSSF(I)
    G3=PIWG1(I)
    G4=SPPP(I)
    ATS1=0.0
    ATS2=0.0
    ATS3=0.0
    ATS4=0.0
    IC=2
    GO TO 21
 41 ATS1=ATS1+(G1+SWW(I))/2.*(OMEG(I)-F1)
    ATS2=ATS2+(G2+SSSF(I))/2.*(OMEG(I)-F1)
    ATS3=ATS3+(G3+PIWG1(I))/2.*(OMEG(I)-F1)
    ATS4=ATS4+(G4+SPPP (I))/2.*(OMEG(I)-F1)
C   ROOT-MEAN SQUARE EQUATIONS
    F1=OMEG(I)
    G1=SWW(I)
    G2=SSSF(I)
    G3=PIWG1(I)
    G4=SPPP(I)
    IF(SWW(I) .LT. SWMI ) SWMI=SWW(I)
    IF(SWW(I) .GT. SWMX) SWMX=SWW(I)
    IF(SSSF(I) .LT. SSMI)SSMI=SSSF(I)
    IF(SSSF(I) .GT. SSMX)SSMX=SSSF(I)
    IF(PIWG1(I) .LT. PIMI) PIMI=PIWG1(I)
    IF(PIWG1(I) .GT. PIMX) PIMX=PIWG1(I)
    OMEGA=      OMEGA* CON
 21 CONTINUE
    KM=I
    GO TO 98
 99 KM=I-1
 98 PAS=ATS4
    AT1=SQRT(ATS1)
```

```
      AT2=SQRT(ATS2)
      AT3=SQRT(ATS3)
      AT4=SQRT(ATS4)
      PA=AT4
      RLA=170.576+10.*ALOG10(PAS)
      END FILE 3
      REWIND 3
      CALL PRNT
      DSW = SWMX/1.E9
      DSS = SSMX/1.E9
      DPI = PIMX/1.E9
      DO 301 I=1,KM
      IF(SWW(I) .LT. DSW) SWW(I)=DSW
      IF(SSSF(I) .LT. DSS) SSSF(I)=DSS
      IF(PIWG1(I) .LT. DPI) PIWG1(I)=DPI
  301 CONTINUE
C     PLOT EXCITATION, DISPLACEMENT, STRESS, AND ACCELERATION
      CALL SCOUTV
      CALL QUIK3V(-1,44,BCDX,BCDY1,-N3R,F3RD,SPPF)
      WRITE (16,109)RLA
      CALL SMXYV(1,1)
      CALL QUIK3V(-1,44,BCDX,BCDY2,-KM,OMEG,SWW)
      WRITE (16,106) AT1,FINN
      CALL QUIK3V(-1,44,BCDX,BCDY3,-KM,OMEG,SSSF)
      WRITE (16,106) AT2,FINN
      CALL QUIK3V(-1,44,BCDX,BCDY,-KM,OMEG,PIWG1)
      WRITE (16,106) AT3,FINN
      CALL QUIK3V(-1,44,BCDX,BCDY4,-KM,OMEG,SPPP)
      WRITE (16,107) PA
      CALL CLEAN
  106 FORMAT(11X,31H    ROOT-MEAN-SQUARE RESPONSE =    E15.7,5X,6HFINN =
     1F6.2,10X,6HRSFRP1 )
  107 FORMAT(11X,30H   ROOT-MEAN-SQUARE PRESSURE =,E15.7)
  108 FORMAT(107H1DYNAMIC RESPONSE OF TWO-OPPOSITE-SIDE SIMPLY-SUPPORTED
     1 AND OTHER TWO SIDES FIXED RECTANGULAR SHELL PANELS,/,
     228H UNDER RANDOM PRESSURE FIELD)
  109 FORMAT(11X,24HOVERALL PRESSURE LEVEL = E15.7,8HDECIBELS)
      RETURN
      END
$DATA
    4   31
         47.50          58.375     .000251          .1
           .04           23.75       29.1875          30.0
     10.           13500.       45.               50.
   0.          10000000.     12000000.       .3
  11.9         14.6           .5             .6
   1.               .12             100.          .00026
    5.0    129.0      6.3    131.0      8.0    133.0     10.0    135.0
   12.5    136.5     16.0    138.0     20.0    139.0     25.0    140.5
   31.5    142.0     40.0    143.0     50.0    144.0     63.0    145.0
   80.0    145.5    100.0    146.0    125.0    146.5    160.0    146.5
  200.0    147.0    250.0    147.0    315.0    146.0    400.0    145.5
  500.0    145.5    630.0    144.0    800.0    142.5   1000.0    141.0
 1250.0    139.5   1600.0    137.5   2000.0    136.0   2500.     134.5
 3150.   133.    4000.    131.     5000.    129.5
```

I. METHODS OF VERIFICATION

Comparison of the computed results with experimental data is the best verification. Verification can also be obtained by hand calculation of the responses according to the simple formulas by assuming the structure vibrates in its fundamental mode.

The root-mean-square responses are computed, printed, and plotted out as output. Good engineering judgement on these rms responses may also serve as a check of the results.

SECTION III. DECK SET-UP

A. Computer Configuration

1. Computer IBM 7094
2. Core Size 32K
3. Language FORTRAN IV
4. Operating System IBSYS
5. Plotter Required SC4020
6. Punch NO
7. Tape Assignments

Physical Unit	Logical Unit	System Function
A2	5	Input
A4	3	System Scratch
A8		SC 4020 Output
B1	6	Print Output
B3	2	System Scratch Overlay

B. Estimated Running Time

Execution time is approximately 55 minutes for all three boundary conditions, for frequency range 5 to 5000 Hertz, and frequency increment FINN = 33.

C. Restart Procedure

None

D. Deck Sequence

1. $JOB CARD
2. $EXECUTE CARD
3. $IBJOB CARD
4. $IBFTC CARD
5. SOURCE DECK (RANDOM)
6. $IBFTC CARD
7. SOURCE DECK (SUBROUTINE PRNT)
8. $IBFTC CARD
9. SOURCE DECK (SUBROUTINE GRIDIV)

10. $ORIGIN CARD
11. $IBFTC CARD
12 SOURCE DECK (SUBROUTINE RSR)
13 $ORIGIN CARD
14. $IBFTC CARD
15. SOURCE DECK (SUBROUTINE RFR)
16. $ORIGIN CARD
17. $IBFTC CARD
18. SOURCE DECK (SUBROUTINE RSF)
19 $DATA CARD
20. DATA DECK

E. INPUT DATA

Refer to Figure 1 for geometric dimensions.

NOTATION		DEFINITION	CARD		
FORMULAS	MNEMONICS		NO.	FORMAT	COL.
	NP	Program desired - NP = 1 (RSR) NP - 2 (RFR), NP = 3 (RSF), NP = 4 (ALL)	1	I5	Col. 5
	N3R	Number of data points in the one-third octave band excitation spectrum	1	I5	Col. 6-10 Right Justified
ℓ	PL	Axial length of panel (inches) (Along x-axis)	2	E15.8	Col. 1-15
b	B	Width of Panel (inches) (Along y-axis)	2	E15.8	Col. 16-30
ρ	RHO	Mass density of panel skin ($lbf\text{-}sec^2/in^4$)	2	E15.8	Col. 31-45
h	HS	Thickness of panel skin (inches)	2	E15.8	Col 46-60
ζ_{jk}	CI	Damping ratio of panel	3	E15.8	Col 1-15
x	X	Coordinate of $\vec{r}$ (inches)	3	E15.8	Col. 16-30
y	Y	Coordinate of $\vec{r}$ (inches)	3	E15.8	Col. 31-45
n	FINN	One-nth octave frequency increment	3	E15.8	Col. 46-60
A_1	A1	Correlation decay constant in axial length-direction	4	E15.8	Col. 1-15
c	C	Speed of sound (in/sec)	4	E15.8	Col 16-30
ℓ'	PLP	Length of panel subjected to excitation (inches)	4	E15.8	Col. 31-45
b'	BP	Width of panel subjected to excitation (inches)	4	E15.8	Col. 46-60

NOTATION		DEFINITION	CARD		
FORMULAS	MNEMONICS		NO.	FORMAT	COL.
A_2	A2	Correlation decay constant in circumferential width-direction	5	E15.8	Col. 1-15
E	E	Young's modulus of panel skin (lbf/in^2)	5	E15.8	Col. 16-30
E'	EP	Young's modulus of stiffeners (lbf/in^2)	5	E15.8	Col. 31-45
ν	VIP	Poisson's ratio of panel skin	5	E15.8	Col. 46-60
a_1	AL1	Spacing of width-direction stiffeners (inches)	6	E15.8	Col. 1-15
b_1	BL1	Spacing of length-direction stiffeners (inches)	6	E15.8	Col. 16-30
I_1	AI1	Moment of inertia of one length-direction stiffener with respect to neutral axis ($inch^4$)	6	E15.8	Col. 31-45
I_2	AI2	Moment of inertia of one width-direction stiffener with respect to neutral axis ($inch^4$)	6	E15.8	Col. 46-60
h_2	H2	Largest height of stiffeners at point investigated (inches)	7	E15.8	Col. 1-15
h'	HP	Smeared-out thickness of stiffeners (inches)	7	E15.8	Col. 16-30
a	RAD	Radius of panel (inches)	7	E15.8	Col. 31-45
ρ	RHOP	Mass density of stiffeners ($lbf\text{-}sec^2/in^4$)	7	E15.8	Col. 46-60
f	F3RD	Frequencies (Hertz)	4 Values Per Card	F8.1	Col. 1-8,17-24 33-40, 49-56
$S_{3r}(I)$	S3RD	One-third octave pressure level spectrum of excitation (decibels)	4 Values Per Card	F8.1	Col. 9-16,25-32 41-48, 57-64
		Use as many cards as necessary for F3RD and S3RD			

F. Restrictions and Limitations

$N3R \leq 40$

$FINN \leq 38$

G. Diagnostics

None

H. Quanity of Output

For case with frequency range of 5-5000 Hertz and frequency increment FINN = 33, the printed output will be 20 pages per boundary condition. Plots will be 5 per boundary condition.

I. Output Definitions

NOTATION		DEFINITION
FORMULAS	MNEMONICS	
ℓ	PL	Axial length of panel (inches)
b	B	Width of panel (inches)
ρ	RHO	Mass density of panel skin ($lbf\text{-}sec^2/in^4$)
h	HS	Thickness of panel skin (inches)
ζ_{jk}	CI	Damping ratio of panel
x	X	Coordinate of $\vec{r}$ (inches)
y	Y	Coordinate of $\vec{r}$ (inches)
n	FINN	One-nth octave frequency increment
A_1	A1	Correlation decay constant in axial length-direction
c	C	Speed of sound (in/sec)
ℓ'	PLP	Length of panel subjected to excitation (inches)
b'	BP	Width of panel subjected to excitation (inches)
A_2	A2	Correlation decay constant in circumferential width-direction
E	E	Young's modulus of panel skin (lbf/in^2)
E'	EP	Young's modulus of stiffeners (lbf/in^2)
ν	VIP	Poisson's ratio of panel skin
a_1	AL1	Spacing of width-direction stiffeners (inches)
b_1	BL1	Spacing of length-direction stiffeners (inches)
I_1	AI1	Moment of inertia of one length-direction with respect to neutral axis ($inch^4$)

I. Output Definitions (Continued)

NOTATION		DEFINITION
FORMULAS	MNEMONICS	
I_2	A12	Moment of inertia of one width-direction stiffener with respect to neutral axis (inch^4)
h_2	H2	Largest height of stiffeners at point investigated (inches)
h'	HP	Smeared-out thickness of stiffeners (inches)
a	RAD	Radius of panel (inches)
ρ'	RHOP	Mass density of stiffeners (lbf-sec^2/in.^{4})
f	F3RD	Frequencies (Hertz)
$S_{3r}(I)$	S3RD	One-third octave pressure level spectrum of excitation (decibels)
$S_{pp}(f)$	SPPF(I)	Excitation spectral density (db/Hz)
$\phi_{pp}(\omega)$	FIPW(I)	Excitation spectral density (psi^2/rad/sec)
j	J	Mode
k	K	Point
f	FHZ	Natural frequencies (Hz)
ω_{jk}	FNW(J,K)	Natural frequencies (rad/sec)
f	OMEG(I)	Frequency (independent variable) (Hz)
$S_{ww}(\vec{r},f)$	SWW(I)	Displacement spectral density (inch^2/Hz)
$S_{\sigma\sigma}(\vec{r},f)$	SSSF(I)	Stress spectral density (psi^2/Hz)
$S_{\ddot{w}\ddot{w}}(\vec{r},f)$	PIWG1(I)	Acceleration spectral density (G^2/Hz)
$S'_{pp}(f)$	SPPP(I)	Excitation spectral density (psi^2/rad/sec)
$w^2(\vec{r})$	ATS1	Mean square displacement (inch^2)
$\sigma^2(\vec{r})$	ATS2	Mean square stress (psi)^2
$G^2(\vec{r})$	ATS3	Mean square acceleration (g^2)
$w(\vec{r})$	AT1	Root-mean square displacment (inch)

I. Output Definitions (Continued)

NOTATION		DEFINITION
FORMULAS	MNEMONICS	
$\sigma(\vec{r})$	AT2	Root-mean square stress (psi)
$G(\vec{r})$	AT3	Root-mean square acceleration (g)
Q_x	QX	Quantity for the calculation of γ^2
Q_y	QY	Quantity for the calculation of γ^2
Q_w	QW	Quantity for the calculation of γ^2
$\gamma^2(\vec{r})$	GAM2	Constant to change displacement spectral density into stress
j,k,m,n	J,K,M,N	Mode Indices
J^2_{jkmn}	POWJ2	Joint acceptance squared

J. Operator Instruction Card

7094-__________ INSTRUCTIONS

NAME MOORE		OP CODE 12	STACK #
BIN # 216	LOC 4663	JOB # 490530	

IF EXCEEDS MAX

☐ STR ☐ STZ ☐ DMP ☐ RETSY

☒ IBSYS
☐ SPOOK
☐ OTHER

☒ COMPL /ASSMBL
☒ EXECUTE
☐ PUNCH (BCD BIN)

☒ 4 FTRN
☐ 2 FTRN
☐ APT
☐ PERT

☐ MAP
☐ FAP
☐ SCAT
☐ OTHER

FAST TAPES A B C D

INPUT TAPES			WORK
LOGIC	REEL NO	DEN	LOGIC

LINES OF OUTPUT (1000'S)

☐ 0-5 ☐ 5-15 ☐ 15-30 ☐ OVER

MAXIMUM TIME

HOURS ____ MINUTES 55

PROGRAMMER COMMENTS

NUMBER OF CASES ________

OVER ____

☐ SEE ON-LINE
☐ SEE TECHNIQUES
☐ MAX EXCEEDED
☐ RETURN TO SYS
☐ LINE MAX

OPERATOR COMMENTS

OPER INIT ____
OVER ____

OUTPUT TAPES ONLY						4020
REEL NO	LOGIC	DEN	UNIT	NO OF CPYS	SAVE	TAPE
	B-1	8				
	A-8					✓

NO FILES	NO FRAMES	COPIES		DENSITY		COPY FLO		KALVAR
		P	F	5	8	P	F	
1	15					✓		

MSFC - Form 533 (Rev February 1966)

K. Save Labels

None

L. INPUT FORM (SAMPLE CASE)

4	31		
47.5	58.375	.000251	0.1
0.04	23.75	29.1875	30.0
10.0	13500.0	45.0	50.0
0.0	10000000.	12000000.	0.3
11.9	14.6	0.5	0.6
1.	0.12	100.0	0.00026

5.0	129.0	6.3	131.0	8.0	133.0	10.0	135.0
12.5	136.5	16.0	138.0	20.0	139.0	25.0	140.5
31.5	142.0	40.0	143.0	50.0	144.0	63.0	145.0
80.0	145.5	100.0	146.0	125.0	146.5	160.0	146.5
200.0	147.0	250.0	147.0	315.0	146.0	400.0	146.5
500.0	145.5	630.0	144.0	800.0	142.5	1000.0	141.0
1250.0	139.5	1600.0	137.5	2000.0	136.0	2500.0	134.0
3150.0	133.0	4000.0	131.0	5000.0	129.5		

M SAMPLE OUTPUT

SAMPLE OUTPUT OF PROGRAM RANDOM

FREQUENCY HERTZ	DISPLACEMENT RESPONSE INCH SQ/HERTZ	STRESS-RESPONSE PSI SQ/HERTZ	ACCELERATION RESPONSE G SQ/HERTZ	EXCITATION PSI SQ/RAD/SEC
5.00000	0.22106171E-06	0.33402308E 03	0.14445757E-05	0.60100626E-04
5.00000	0.22106171E-06	0.33402308E 03	0.14445757E-05	0.60100626E-04
5.11687	0.22497937E-06	0.33994264E 03	0.16125262E-05	0.61493802E-04
5.23647	0.22894313E-06	0.34593186E 03	0.17998198E-05	0.62919542E-04
5.35887	0.23295265E-06	0.35199022E 03	0.20086596E-05	0.64378608E-04
5.48412	0.23700746E-06	0.35811703E 03	0.22414964E-05	0.65871778E-04
5.61231	0.24110694E-06	0.36431132E 03	0.25010540E-05	0.67399849E-04
50.39679	0.21680200E-06	0.32758667E 03	0.14622498E-01	0.19004992E-03
51.57476	0.21359602E-06	0.32274247E 03	0.15801152E-01	0.19003523E-03
52.78026	0.21047653E-06	0.31802892E 03	0.17077983E-01	0.19002020E-03
54.01394	0.20744474E-06	0.31344790E 03	0.18461741E-01	0.19000482E-03
55.27646	0.20450190E-06	0.30900129E 03	0.19962038E-01	0.18998907E-03
56.56848	0.20164937E-06	0.30469114E 03	0.21589457E-01	0.18997296E-03
57.89071	0.19888860E-06	0.30051962E 03	0.23355655E-01	0.18995647E-03
59.24384	0.19622106E-06	0.29648898E 03	0.25273482E-01	0.18993960E-03
60.62859	0.19364840E-06	0.29260171E 03	0.27357141E-01	0.18992233E-03
62.04572	0.19117232E-06	0.28886037E 03	0.29622325E-01	0.18990466E-03
192.48369	0.64212375E-06	0.97024561E 03	0.92159750E 01	0.96834247E-04
196.98278	0.88668852E-06	0.13397817E 04	0.13958249E 02	0.95617973E-04
201.58703	0.13158538E-05	0.19882482E 04	0.22719816E 02	0.94200486E-04
206.29890	0.20998010E-05	0.31727882E 04	0.39766065E 02	0.92413703E-04
211.12091	0.33107326E-05	0.50024996E 04	0.68769506E 02	0.90585155E-04
216.05563	0.36595516E-05	0.55295632E 04	0.83375221E 02	0.88713867E-04
221.10569	0.23061066E-05	0.34845150E 04	0.57626974E 02	0.86798839E-04
226.27378	0.11954749E-05	0.18063562E 04	0.32766058E 02	0.84839051E-04
231.56268	0.64654001E-06	0.97691854E 03	0.19436429E 02	0.82833453E-04
236.97520	0.37834190E-06	0.57167262E 03	0.12475065E 02	0.80780978E-04
570.17398	0.42722072E-09	0.64552825E 00	0.47209420E 00	0.20496707E-04
583.50116	0.49555338E-09	0.74877855E 00	0.60062600E 00	0.19290879E-04
597.13985	0.50793323E-09	0.76748443E 00	0.67523918E 00	0.18056867E-04
611.09732	0.32488827E-09	0.49090447E 00	0.47372068E 00	0.16794010E-04
625.38104	0.15372795E-09	0.23228212E 00	0.24585468E 00	0.15501636E-04
639.99863	0.94628312E-10	0.14298288E 00	0.16599081E 00	0.14691158E-04
654.95788	0.84418406E-10	0.12755577E 00	0.16241921E 00	0.14103838E-04
670.26678	0.94198362E-10	0.14233323E 00	0.19878378E 00	0.13502788E-04
685.93353	0.11849360E-09	0.17904321E 00	0.27426463E 00	0.12887691E-04
701.96645	0.16238162E-09	0.24535777E 00	0.41223900E 00	0.12258216E-04
4063.73444	0.33002897E-16	0.49867203E-07	0.94102274E-04	0.11577557E-06
4158.71967	0.27798077E-16	0.42002749E-07	0.86936097E-04	0.11087127E-06
4255.92511	0.23363096E-16	0.35301515E-07	0.80140694E-04	0.10585232E-06
4355.40265	0.19584142E-16	0.29591536E-07	0.73682540E-04	0.10071606E-06
4457.20532	0.16364966E-16	0.24727378E-07	0.67532444E-04	0.95459756E-07
4561.38745	0.13623937E-16	0.20585697E-07	0.61664792E-04	0.90080588E-07
4668.00482	0.11291682E-16	0.17061671E-07	0.56057096E-04	0.84575686E-07
4777.11420	0.93091068E-17	0.14066011E-07	0.50689418E-04	0.78942112E-07
4888.77393	0.76258003E-17	0.11522544E-07	0.45544091E-04	0.73176862E-07
MS VALUE	0.12538172E-03	0.18945116E 06	0.24598280E 04	0.51435825E-01
RMS VALUE	0.11197398E-01	0.43525988E 03	0.49596653E 02	0.22679467E 00

QX = 0.37250E-01 QY = 0.29523E-01 QW = 0.73903E 01 GAMMA2 = 0.15110E 10
FINN = 30.0

N. Sample Plots

Figure 2 through 4 are three sample plots of this program.

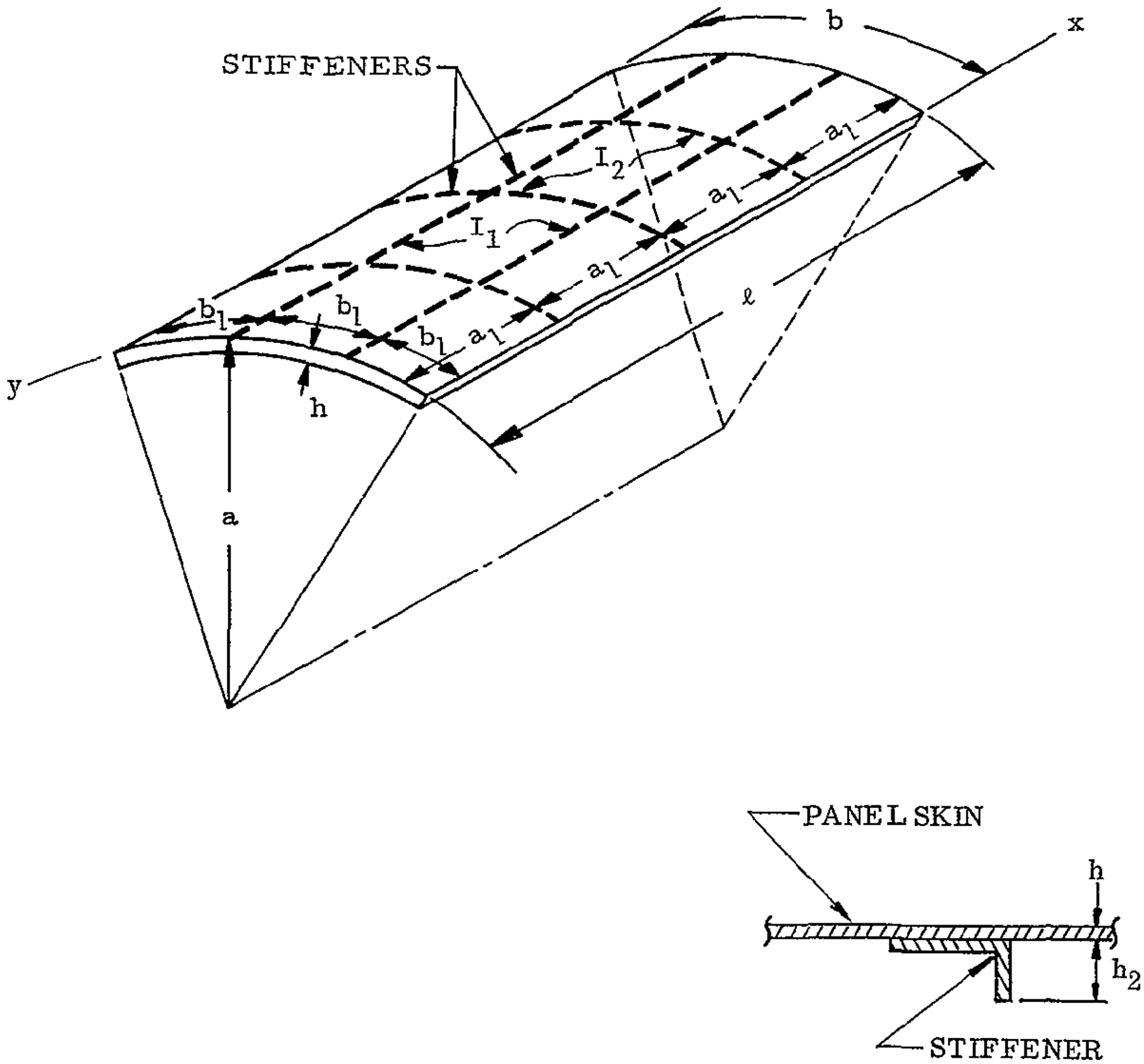


FIGURE 1. GEOMETRY OF RECTANGULAR CYLINDRICAL SHELL PANEL CROSS-REINFORCED WITH STIFFENERS

RUN 9582

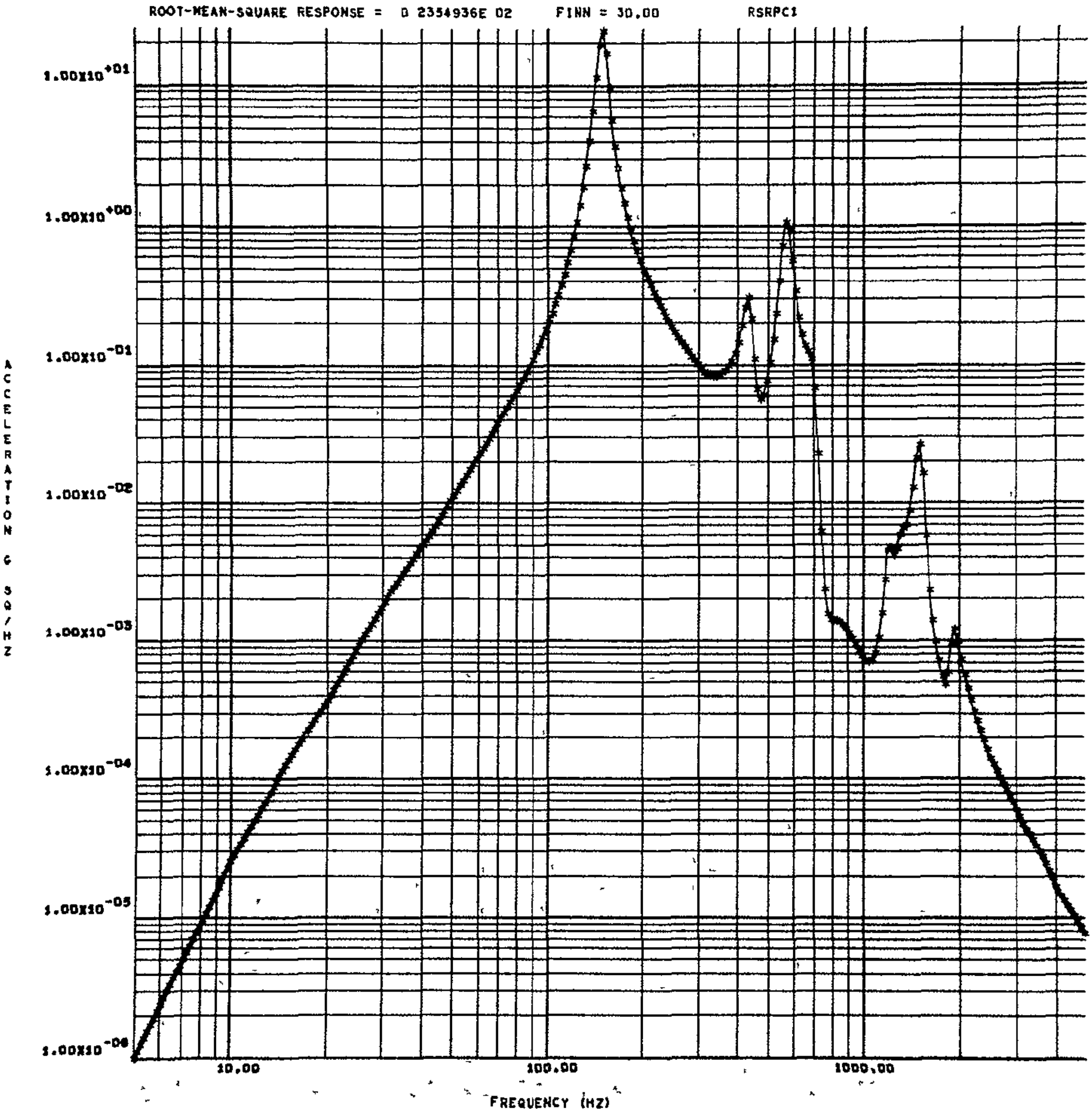


FIGURE 2. SAMPLE PLOT: ACCELERATION SPECTRAL DENSITY AT CENTER OF FOUR EDGES SIMPLY-SUPPORTED RECTANGULAR CURVED PANEL CROSS-REINFORCED WITH STIFFENERS

RUN 9582

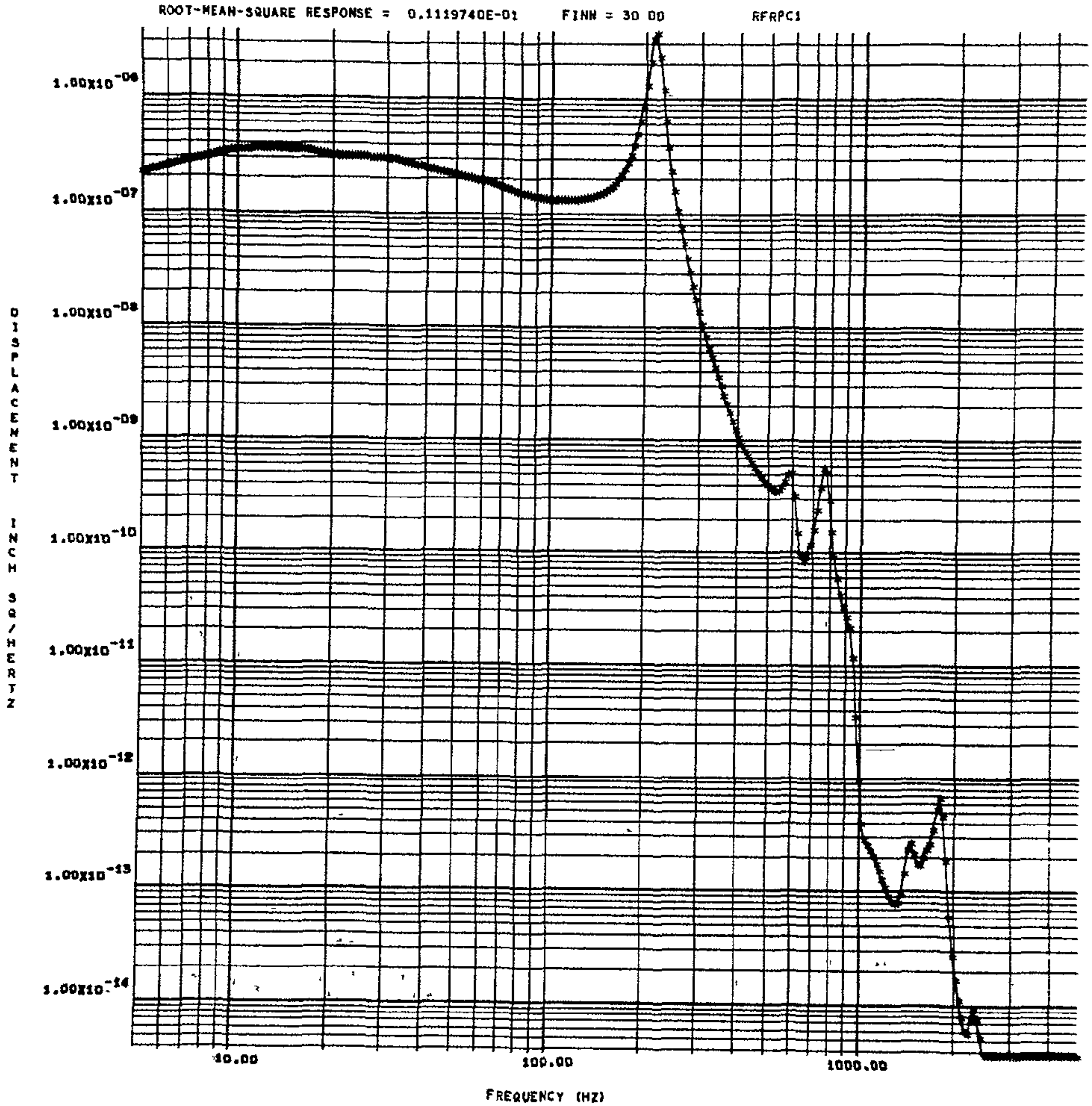


FIGURE 3. SAMPLE PLOT: DISPLACEMENT SPECTRAL DENSITY AT CENTER OF FOUR EDGES CLAMPED RECTANGULAR CURVED PANEL CROSS-REINFORCED WITH STIFFENERS

RUN 9582

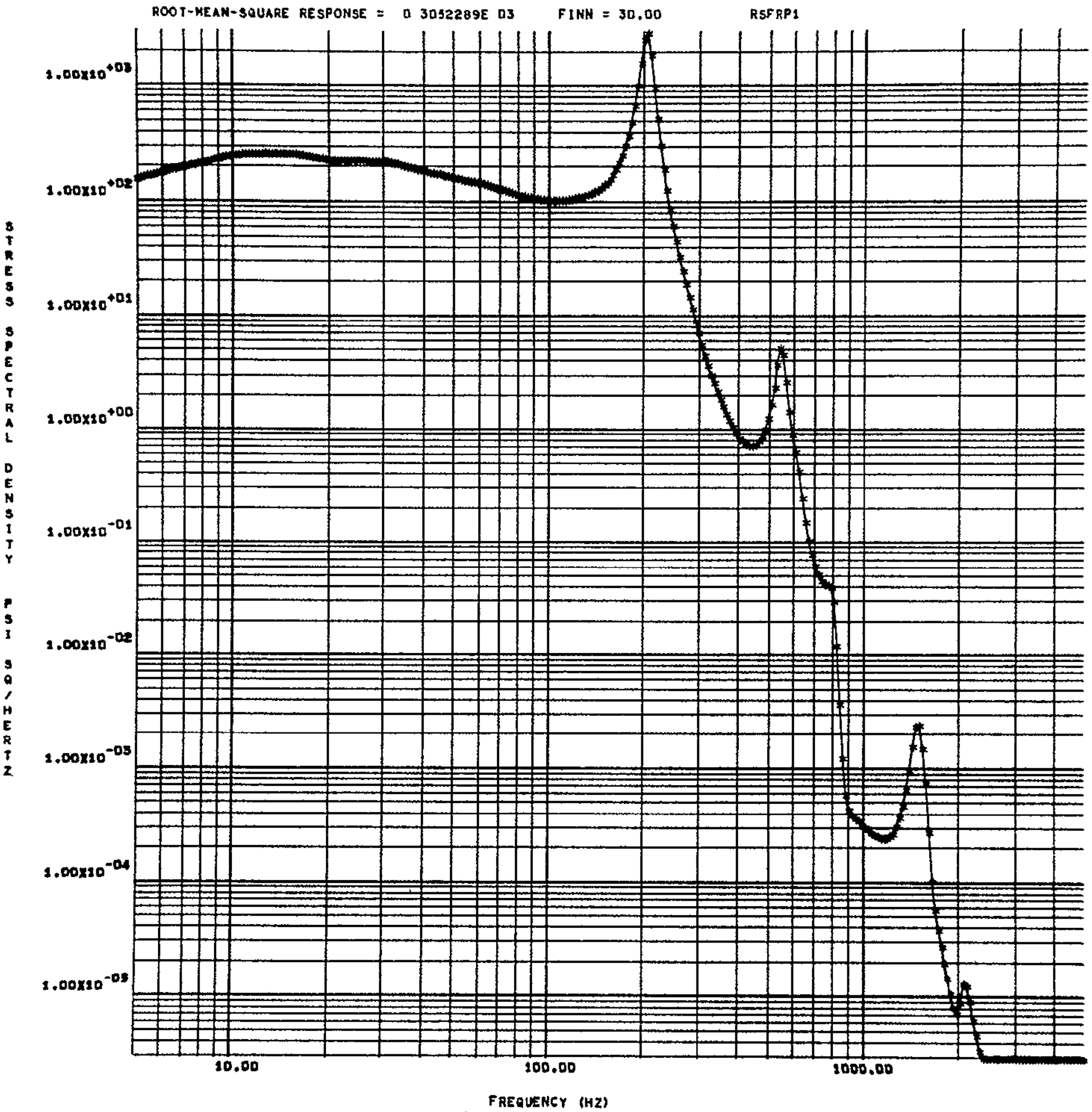


FIGURE 4. SAMPLE PLOT: STRESS SPECTRAL DENSITY AT CENTER OF TWO OPPOSITE EDGES SIMPLY-SUPPORTED WHILE OTHER TWO CLAMPED RECTANGULAR CURVED PANEL CROSS-REINFORCED WITH STIFFENERS

Technical Report HSM-R29-69 Contract NAS8-21403
July 31, 1969

FINAL REPORT

COMPUTER PROGRAMS FOR PREDICTION OF STRUCTURAL VIBRATIONS DUE TO FLUCTUATING PRESSURE ENVIRONMENTS

VOLUME TWO

USERS' MANUAL
FOR
PROGRAM RANDOM

By Tsin Nien Lee
Tsin Nien Lee

and James Kermit Moore
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